STUDY ON RUNOFF FACTOR AND CROPPING MANAGEMENT FACTOR OF SOIL LOSS EQUATION AT AKOLA

THESIS

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Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
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DECLARATION OF STUDENT

I hereby declare that the experimental work and it's interrelation of the thesis entitle "study on runoff factor and cropping management factor of soil loss equation at Akola". Or part there of has not been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis publication of any University or Scientific organization. The source of material used and all assistance received during the course of investigation have been duly acknowledged.

Place : Akola
Date :27/05/2002

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CERTIFICATE

This is to certify that the thesis entitled "Study on runoff factor and cropping management factor of soil loss equation at Akola"" submitted in partial fulfillment of the requirements for the degree of Master of Technology in Agricultural Engineering (Soil and water conservation Engineering) of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of banafied research work carried out by Sima Rajaram Mundle under my guidance and supervision. The subject of thesis has been approved by the student's advisory committee.

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ABBREVIATIONS

%	:	Per cent
AEEC	:	Agro-ecology and Environment Center
ASAE	:	American Society of Agricultural Engineers.
Assoc		Association
Asstt	:	Assistant
C	:	Cropping management factor
cm	:	Centimeter
CSWCRTI	:	Central soil and Water Conservation research and Training Institute
Deptt	:	Department
et al.,	:	And other
Fig.	:	Figure
IARI	:	Indian Agricultural Research Institute
ICAR	:	Indian Council of Agricultural Research Institute
IMD	:	Indian Meteorological Department
K.E.	:	Kinetic energy
LS	:	Topographic factor
MPKV	:	Mahatma Phule Krishi Vidyapeeth
USDA	:	United States Department of Agricultural
USLE	:	Universal Soil Loss Equation

CHAPTER – I

INTRODUCTION

The basic need of mankind are food, fibre and shelter. Food is fully dependent on agriculture, where soil and water are two major natural resources essential for crop production.

The natural balance between soil forming and soil conserving process has been affected leading to serious problem of erosion due to consequence of increasing pressure on land, in which soil slips and slides away at an alarming rate under the action of wind and running water. This process of erosion increases by leaps and bounds when natural protection of the soil is lost(Ellison, 1944).

Rainfall is the most responsible factor for the soil erosion, because energy of rain is utilized in breaking down of aggregates in their splash, in causing turbulence, scoring and transportation of particles. Soil erosion due to rainfall is a complex phenomenon (Pratap Narayana, 1982). As the chiefagent of erosion, water carries with it all the loose soil that gets deposited in the reservoirs and dams reducing both their storage capacities and life span and the most important thing it distract the fertile agriculture land. The increase velocity of water due to absence of control does not allow it enough time to infiltrated and recharge the groundwater reservoirs and there is lowering of water table. Thus despite adequate rainfall, a region is often found to be water deficient.

The serious soil erosion problem in our country is mainly in the form of sheet erosion, in which top soil is removed in the form of layer through over land flow from the soil surface. The black soils

which are normally cultivated and kept fallow during rainy seasons, are also affected by serious water erosion problem.

All over the world, where ever man has cultivated sloping land, there has been soil erosion to some degree. The history of soil erosion is an integral part of the history of agriculture. Exploitive agricultural, accompanied by cutting of forests on the catchment of rivers, began to the down of history. Cleaning of forest may today provide a few more tonnes of grains, but in a long run as soil get washed away, waste land soil erosion has been responsible for the fall of various ancient civilizations. The removal of the forests increased the number and intensity of floods.

Das (1985) reported that, about 51% (167 m ha/329 m ha) area of total geographical area of India is affected by serious water erosion, due to shifting cultivation and from cultivable watershed. The rate of soil erosion in different soils by sheet erosion is estimated as 4 to 10 t/ha/year in red soils, 17 to 43 t/ha/year in black soils and 4 to 14 /ha/year in alluvial soils. The rate of soil erosion from gullies is computed as 33 t/ha/year in revine regions. Similarly the range of soil erosion from hill side varies more than 80 t/ha/year. Narayana and Rambabu (1983) reported that annual soil loss erosion rates in our country estimates about 5333 million t i.e. 16.35 t/ha/year. About 480 m. t of soils are deposited into various reservoirs of the country.

Since this situation is practically in irreversible, it would be prudent to accept it and proceed from there. Which are the best measures by which we can assure a better livehood of people without causing further damage to these valuable resources is an issue that demands immediate attention. An optimum rather than maximum

utilization of resource and adopting a strategy and approach that is sustainable is perhaps the best solution.

Soil erosion tolerance values, an indicator of acceptable yearly soil loss, were first developed in united states bared on estimation of a surface soil formation of 25 mm in 30 years. In other words 11 t/ha/yr and has been basis for setting acceptable annual soil loss rates in US (Horne, 1991).

For sound soil and water conservation planning reliable soil loss estimation is a valuable tool in designing, planning and extension. and the soil loss will be within the allowable limits.

Wischmeier and Smith (1965) developed USLE based on nearly 10,000 plot year, runoff plot data. This equation was later refined with more recent data from runoff plots, rainfall simulations and field experiences (Wischmeier and Smith 1978) . And this equation is most widely used for the estimation of average annual soil loss. In USLE, various parameters such as rainfall erosivity index or rainfall factor (R), soil erodibility factor (k), topographic factor (LS), cropping management factor (c) and conservation practice factor (P) are considered for the estimation of average annual soil loss.

The USLE does not compute the sediment yield from the watershed directly. Soil loss from the watershed is computed with the help of USLE and delivery ratio of watershed is multiplied to the computed soil loss to obtain the sediment yield.

To overcome above demerit, Williams (1975), made on effort to modify USLE fit for computation of sediment yield either monthly or seasonal. He modified USLE (MUSLE) by replacing the rainfall energy factor (R) with another factor called as runoff factor.

The cropping management factor (C) is the expected ratio of soil loss from crop under specified crop to soil loss from continue fallow land, provided that the soil type, slope and rainfall conditions are identical. The crop and cropping practices affect the soil erosion in many ways by their various features. Such as kind of crops quality of cover, root growth. It is also significant that these features differ variously within the crop growing period and according the soil loss gets affected. Estimation of cropping management factor of various location is essential as rainfall pattern and crops changes region to region.

The research and experiences since 1970 have provided improved technology that is incorporated in new, revised USLE (RUSLE), makes it possible to compute it by sub factors ,Prior Land Use (PLU) Surface Roughness (SR), Surface cover (SC), Crop canopy (CC) and Soil Moisture (SM).

The RUSLE includes analysis of data not available at the time of preparation of the previous handbooks. The analyses are documented so that others can review, evaluate and /or repeat them in the process of making local analyses.

This information can be used for designer and planner to predict soil loss and plan a proper cropping and management system so that the soil loss is within the allowable limit.

Keeping all above point in view the research work entitled **"Study on runoff factor and cropping management factor of soil loss equation at Akola"** is proposed to be undertaken with following objectives.

1. To estimate runoff factor of MUSLE.

2. To estimate cropping management factor of USLE for cotton and bajra at Akola.

3. To estimate cropping management factor of RUSLE for commonly grown kharif crops at Akola.

CHAPTER – II

REVIEW OF LITERATURE

Erosion is greatest destroyer of land resources. In addition to losses of soil, many other problems are created by soil erosion like, siltation of reservoirs, deposition of unfertile material on cultivated lands, harmful effects on water supply, fishing, power generation and most important destruction of fertile agricultural land.

Land management is the science of selecting most appropriate agriculture use for land, which helps to the soil conservation planner to evaluate the various alternative treatments as related to the amount of expected soil loss.

There are many soil loss prediction equations developed by several investigators. Wischmeier and Smith, 1965 developed the universal soil loss equation (USLE) based on nearly 10,000 plot year with more recent data from runoff plots, rainfall simulations and field experience (Wischmeier and Smith 1978) is most widely used equation for the estimation of soil loss.

Williams (1975) modified the USLE by rainfall erosivity factor (R) with runoff factor for computation of sediment yield.

Knneth (1991) developed the revised USLE (RUSLE) by cooperative efforts between scientists and users as improved technology for estimation of C factor.

The work done by various research workers on different parameter of USLE, runoff factor for MUSLE, cropping management

factor for RUSLE in the past are reviewed and presented under the following heads.

1. Rainfall erosivity factor.
2. Soil erodibility factor.
3. Topographic factor.
4. Cropping management factor.
5. Supporting conservation practice factor.

UNIVERSAL SOIL LOSS EQUATION

$$A = RKLSCP \text{ ---------- } (2.1)$$

Where,

A = Average annual soil loss, (t/ha)

R = Rainfall erosivity index (metric units)

K = Soil erodibility factor (t/ha/R)

L = Length of slope factor.

S = Steepness of slope factor

C = Cropping management factor

P = Supporting conservation practice factor

2.1 RAINFALL EROSIVITY FACTOR (R)

According to Hudson rainfall erosivity is the potential ability of rain to cause erosion. The amount of erosion depends upon a combination of power of rain to cause erosion and ability of the soil to withstand the rain. In mathematical term erosion is a function of the erosivity (of the rain) and the erodibility (of the soil).

Wischmeier (1959) developed the method for rainfall erosion index for the USLE. Extensive regression analysis of basic soil-loss data was designed to determine the best indicator of the capacity of a storm to erode soil. The rainstorm characteristics found to be outstanding as such an indicator is the variable whose value is the product of rainfall energy and maximum 30-minute intensity of the storm.

Wishchmeier and Smith (1978) showed that the factor most closely related to the erosion was the kinetic energy of the rain. The best estimation of the soil loss was found to be compound parameter, the product of kinetic energy of storm and 30 minutes intensity. This measure of erosivity was described as the EI_{30} index..

Foster *et al.* (1982) evaluated the rainfall-runoff erosivity factors for individual storms. The USLE is widely used to satisfactory estimate average annual soil loss from rainfall without modification. It is somewhat unsatisfactory for estimating soil loss from individual storms. Several erosivity factors that could be used to estimate soil loss from individual storm were investigated in this study. Rainfall erosivity factor like EI_{30} that include both rainfall rate and amount term were found to be much better predictor of soil loss, than a factor including rainfall amount alone. Erosivity factors that include rainfall amount, rainfall intensity and runoff amount were even better predictors than EI_{30}, whereas erosivity factors with separate term for rainfall and runoff erosivity were best. However, these factors did not greatly improve soil loss prediction as compared with EI_{30}.

Bhuibhar (1987) worked out average monthly and annual erosion index values for different gauging stations in Vidarbha region. It was found that at Akola, July is the most erosive

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Bhuibhar (1987) worked out average monthly and annual erosion index values for different gauging stations in Vidarbha region. It was found that at Akola, July is the most erosive

months having average erosion index 108.51 metric units followed by August having 86.0 metric units. The annual erosion index varied from as low as 49.55 metric units (1985) to as high as 712.72 metric units (1986) for Akola region. The average annual erosion index for Akola was worked out to be 334.49 metric units.

Erosion index values for Vidarbha region

Station	Erosivity Index (R)					
	June	July	August	Sep	Seasonal	Annual
Akola	50	109	86	65	310	335
Bramhapuri	90	183	185	50	508	575
Buldana	81	30	38	24	173	189
Chandrapur	55	127	177	55	414	451
Gondia	103	158	193	72	526	559
Nagpur	68	106	123	55	352	393
Yeotmal	91	87	69	54	301	324

Karad *et al.* (1991) evaluated the rainfall erosion index for Parbhani. A study was conducted at Department of Agril. Meteorology, MAU, Parbhani. Average EI for Parbhani was found to be 390 metric units.

Atre *et al.* (1997) stated that the present method of determination of rainfall erosion indices suggested by Wischmeier (1959) is laborious and involves many computations. The rainfall data at most of the stations are of non-recording rainguages, from which it is not possible to compute the rainfall erosion indices with the present method. This necessitates the relationship between rainfall erosion indices and rainfall amount. Rainguage charts of ten years (1975-80) and (1987-90) were available at Rahuri. These charts were used to compute rainfall erosion indices and seasonal erosion

indices were of linear nature. But the exponential function was best suited for annual rainfall erosion index and rainfall amount.

Rambabu and Dhyani (2000) calculated the monthly, seasonal and annual erosion index (EI) values for different states of India using IMD, data. The annual EI values at different places are obtained as 643, 599, 1534, 1450, 675, for AP. MH, Kerala, West Bangal and MP.

Bhushan (2000) evaluated monthwise and annual EI_{30} value for year 1999 at Agra station. The annual EI_{30} value for the year was 1377.5, which is highest in last 41 years. The monthwise EI_{30} values were July 198.4 (14.4% of annual), Aug. 1035.7 (75.1% of annual and Sept. 101.7 (7.4% of annual).Selvi (2000) calculated EI_{30} value for Udaga-mandalam. Total EI_{30} value for the year 1999 was 182.46. The month of October recorded the highest value of 68.11 (37.32%) followed by September which recorded 36.22 (19.85%).

Sudhishri (2000) evaluated monthly EI_{30} at Koraput (Orissa) during 1999. Highest monthly EI_{30} was recorded in June (322.4 units) followed by 261.01, 91.02, 73.82, 57.18 and 18.05 units for the months of May, August, September, July and October.

Sthool *et al.* (2001) conducted an experiment at Rahuri during *kharif* 1995 to determine crop management factor. It is revealed that rainfall erosivity factor for the season was 495.4 metric units. Monthwise rainfall erosivity values were 103.74, 118.22, 22.67, 154.32 and 96.45 metric units for the month of June, July, August, September and October, respectively.

2.1.1 Runoff Factor of MUSLE

Foster *et al.*, (1973) made modifications of the USLE and was used by Onstad *et al.*, in sediment yield model for small watersheds as.

$$A = (0.224)W\ KLSCP \qquad \text{----------} \quad (2.2)$$

Where, W is a hydrologic term and the other terms are as defined in the USLE.

$$W = a\ Rst + (1\text{-}a)\ 0.40Q\ (qp)^{1/3} \qquad \text{----------} (2.3)$$

Where,

R = storm rainfall factor

Q = runoff volume in mm

qp = peak runoff rate in mm/hr

A = A coefficient which varies from 0 to 1

Williams (1975) stated that the USLE (Wischmeier and Smith 1965) was developed to predict the soil loss from small areas. To compute the sediment yield by use of USLE, soil loss from watershed is computed with the help of USLE and delivery ratio of watershed is multiplied to the computed soil loss. The value of this product (i.e soil loss x delivery ratio) give the sediment yield from the watershed. Since USLE predicts the annual soil loss, hence only annual sediment yield can be determined by this equation, which is less important for design of water storage structures.

Then he made an effort to modify the USLE fit for computation of sediment yield either monthly or seasonal. He modified the USLE by replacing the erosivity factor (R) with another

factor called 'Runoff factor'. To make this modifications he used the data of 18 small watersheds at Riesel, Taxes Hostings and Nebraska for 778 individual storms on these watersheds. And the MUSLE was developed as,

$$Y = 95 (Q. qp)^{0.56} KLSCP \quad \text{---------(2.4)}$$

Where,

Y = sediment yield for an individual storm (t)

Q = Volume of runoff (acre - feet)

qp = Peak flow rate (cubic feet/sec)

Williams and Bernt (1976) modified the USLE for predicting sediment yield from watersheds using the equation.

$$Y = 11\,800 (Q\ qp)^{0.56} KLSCP \quad \text{--------(2.5)}$$

Where,

Y = Sediment yield from an individual storm, kg

Q = Storm runoff volume, m^3

qp = Peak runoff rate m^3/sec.

K,L,S,C,P as defined in USLE

Griffin (1988) used several forms of USLE along with ANSWERS (Areal Non-point Source Watershed Environmental development Response Simulation) hydrologic / erosion model to estimate soil erosion on topographically non uniform field and farm units. Soil loss estimates using USLE methods aggregated to obtain field and farm averages. ANSWERS was included because it computes erosion over topographically non uniform areas. Sampling density was critical for the USLE method, while element size was critical for ANSWERS. Fundamentally ANSWERS has more desirable

structure than does the fundamental erosion processes of detachment by raindrop impact, detachment by flow and sediment transport by flow. Also, the basic equations in ANSWERS are driven by rainfall and runoff variables.

Duggal (2000) has been carried out a study for the development of runoff and sediment yield models using a historical observations of a micro watershed in the catchment of Patiala – ki-Rao, along the Shivalik foot-hills. A computer program MSEDIMENT was developed to determine peak runoff rate by rational method, runoff depths by curve no methods and sediment yield by MUSLE. The peak runoff rate, runoff depth and sediment yield models were calibrated and validated for microwatershed II. After calibration the developed peak runoff rate models were.

i) For low intensity storms (Intensity up to 5 cm/hr)

$$qp = \frac{CIA^{0.55}}{36} \qquad \text{--------(2.6)}$$

ii) For high intensity storms (Intensity more than 5 cm/hr)

$$q_p = \frac{CIA^{0.95}}{36} \qquad \text{---------(2.7)}$$

Where,

q_p = peak runoff rate m^3/sec

C = runoff coefficient

I = rainfall intensity for the period equal to the time concentration, cm/hr

A = area, ha

In MUSLE, Duggal used for determinations of sediment yield on the event basis was,

$$Sy = 11.8 (Vqp)^{0.56} KLSCP \quad \text{----------(2.8)}$$

Where,

Sy = sediment yield, tonnes

Y = runoff volume, mm

qp = peak runoff rate, m^3/sec

K,L,S,CP are defined in USLE

The simulated values of peak runoff rates show close agreement with historic values in most of the storms. The simulated runoff depth varied within 30 percent from the historic values. The simulated sediment yields wee in close agreement with historic values. The models developed were used for the prediction of peak runoff rate, runoff depth and sediment yield for microwatershed I. The resulted indicate that the model are valid for the Patiala – ki – Rao of Kandi area of Punjab.

2.2 SOIL ERODIBILITY FACTOR (K)

The succeptibility of soil to erosion is the erodibility that is reciprocal of its resistance to erosion. The resistance of soil to erosion depends on many factors i.e. nature of soil, slope of land and kind of cover.

Jami (1998) conducted studies at experimental plot of model watershed, Akola. From the profile pit, undistributed soil samples were collected and analysed for permeability, per cent organic carbon, soil structure and soil texture. The erodibility factor 'K' of the soils was determined using soil erodibility nomograph. The 'K' values were found to be in the range of 0.130 to 0.215. On an

average the soil erodibility factor 'K' for shallow sandy loam soil was 0.20 and for medium deep sandy clay loam soil it was 0.16.

Soil erodibility factor 'K' was also computed plotwise, directly from runoff plot, by analysing rainfall and soil loss data for ten years period. The value of 'K' were 0.048, 0.033, 0.23 and 0.019 for sowing along the slope, sowing across the slope, sowing along the graded bund and contour cultivation, respectively.

Direct measurement of erodibility factor from runoff plot is costly and time consuming. In India there is wide variations in the soils of different agro-climatic regions and it would not be possible to evalute the soil erodiblity factor 'K' of these soils from runoff plot studies. It is therefore, suggested that in future, studies should be undertaken to determine the vaule of 'K based on nomograph suggested by Wischmeier *et al.* (1971). Studies have shown that erodibility factor determined by runoff plots and nomograph compare quite well.

To obtain accurate soil erodibility factor 'K' values from runoff plots, the soil loss must be measured form the continuous fallow runoff plot, tilled up and down the slope. The continuous fallow for this purpose should be tilled and kept free of vegetation for more than two years.

2.3 TOPOGRAPHIC FACTOR (LS)

Length and steepness of slope factor are combined together termed as topographic factor which is ratio of soil loss from a field having specific steepness and length of slope (i.e. 9 % slope, 22.13 m length) to soil loss from cultivated fallow land.

Kurothe and Singh (2000) started an experiment in 1982 to find out the relationship between steepness of land slope and soil loss for Vasad region. The overall result showed the steeper slope would cause more soil erosion. The average soil loss has increased form 17.2 t ha^{-1} at 2 per cent slope to 88.7 t ha^{-1} at 9 per cent slope. During all the years under study a positive linear relationship has been observed between steepness of slope and soil loss. It is also observed that during high rainfall year the regression line would be much steeper which means that the danger of soil erosion would be relatively serious with increasing steepness of slope in areas of higher rainfall. The erosion index during 1999 was 596 metric units whereas the average erosion index was 693 metric units. The soil erodibility factor was 0.09. The 'S' factor calculated by using equation 2 from the observed data is given in following Table.

Soil loss from runoff plots of different slopes

Slope %	Soil loss (t ha^{-1})		'S' factor
	1999	Average*	
2	3.6	17.2	0.19
3	7.5	26.3	0.30
6	17.9	54.2	0.61
9	53.1	88.7	1.00

*Average of 18 years (1982-1999).

Kurothe and Singh (2000) initiated a long term study in 1982 to find out the relationship between length of slope and soil loss from runoff plots having 2 per cent slope in Vasad region.

The study revealed that during first 3 years (1982-84), the soil loss had increased with increasing length of slope upto either

22m or 44 m and then it got declined. However, during the last 15 years (1985 to 1999) of the study the soil loss consistently increased as the length increased from 11 m to 66 m. The 'L factor from observed data of 15 years was also worked out.

From the research it is very clear that the soil loss increases as the length of slope and steepness of slope is increased. (Subhash Chandra and Rao, 1983), conducted a study on plots of 11, 22, 44 and 66 m lengths on 2 per cent slope. From the results it is cleared that the soil loss has increased with the increase in slope up to 44m. At 66m length, the soil loss did not follow the same pattern, which seems similar to the equation suggested by Wischmeier and Smith (1978).

Regarding the topographic factor critical examination of data on various slope lengths and degree of slope revealed that the relationship between the slope length and soil loss is not very clear under Indian conditions. The data for degree of slope are also not sufficient enough to draw any definite conclusions. It would be appropriate to undertake systematic studies in various soil climatic regions of India to determine effect of length of slope and degree of slope on soil loss. The original length and slope factor which was determined by Wischmeier and Smith (1978) were based on soil loss data collected under temperate rainfall conditions where the intensity of rainfall is generally low. The rainfall characteristics of India are entirely different as far as their intensity and duration are concerned and it would be worthwhile to validate the Wischmeier's relationship for Indian conditions. (Dhuruvanarayan, 1993).

2.4 CROPPING MANAGEMENT FACTOR (C)

2.4.1 Cropping Management Factor (C) Suggested by USLE

Cropping management factor is the expected ratio of soil loss from a cropped land and under specific crop to soil loss from continuous fallow land provided that soil type, slope and rainfall conditions are identical. It is most important and complicated factors as there are infinite number of ways of managing the growing crops.

Wischmeier (1960) evaluated the cropping management factor for USLE. About 8000 plot of soil loss and related data assembled from 21 states were analysed to evaluate influence of vegetal growth, crop sequence, tillage practices, fertility and residue management on erosion of soil by rainfall. Specific crop data were grouped according to relatively homogenous intervals such as respective rough fallow, seedbed, establishment, growing crop and residue periods. For each such period, measured soil losses under specific combination of crop sequence and management were compared with corresponding losses from bare fallow.

Agnihotri *et al.* (1975), calculated various factors for universal soil loss equation for two calibrated plots having the same length, width and slope of 150 m, 10 m and 1.5 per cent, respectively.

The value of C for maize has been worked out for different years.

C Values for maize during 1973-76 at Chandigarh

Year	EI_{30} for cropping period*	C values
1973	329.3	0.029
1974	273.9	0.037
1975	451.4	0.013
1976	395.3	0.032
Avg.	362.5	0.026

*EI_{30} for cropping period of maize (part of July, August, September)

Sharma and Panwar (1977) conducted a field experiment at Kanpur under rainfed conditions with the object of studying the effectiveness of various crop covers in reducing soil splash by raindrop impact. The cropping management factor (C) and soil cover ratio of various crops was calculated to find out the effectiveness of crop cover. Urid and groundnut+arhar offered better cover, low cropping management factor (C) and high value of soil cover rating, thereby reducing soil loss to the maximum whereas tall growing crops such as maize, jowar+arhar and bajra +arhar gave poor canopy, high c-factor value and low soil cover rating (R) and hence failed to reduce soil loss efficiently.

McGregor (1978) conducted a study to estimate C factors for no-till and conventional till soybeans from plot data. Cropping and mana-gement (C) values were derived by crop stage periods for conventional till soybeans and no-till soybeans, no-till corn and soybean in rotation, and double-cropped, no-till soybeans and wheat. Annual C values were derived by a weighing procedure. Actual soil loss and rainfall erosion index measurements were used in the derivations. Nema *et al.* (1978) predicted some USLE parameters

from runoff plot studies conducted at Vasad. The crop management factor for mung, groundnut and cowpea were worked out to be 0.456, 0.374 and 0.317, respectively.

Dissmeyer and Foster (1981) estimated the cover management factor in the USLE for forest condition. A new procedure was adopted based on the evaluation of nine sub factors.

1) Amount of bare soil 2) Canopy 3) Soil reconsolidation 4) High organic content 5) Fine roots 6) Residual binding effect 7) on site storage 8) Steps and a) contour tillage. The procedure validated with data from 39 research watersheds provided reasonably good estimates of erosion.

Pratap Narian *et al.* (1982) predicted some parameters of ISLE at Kota. The C factor for various crops namely ground nut, greengram, guar, arhar, urid, Jowar, jowar + arhar, natural cover and *Dichanthium annulatum* and *Cynadon dactylon* grasses were worked out. The C factor for various kharif legumes ranged between 0.386 to 0.427, for cereals between 0.502 to 0.619 and for natural cover and grass 0.01 to 0.22. Amongst *kharif* legumes order of soil protection was cowpea > green gram > groundnut soybean > blackgram > cluster bean.

Bhushan and Omprakash (1983) initiated a runoff plot study on 2 per cent slope to evaluate different cropping systems for runoff and soil loss. Average of three years result indicated that maximum runoff (258 mm i.e. 50 per cent of rainfall) and soil loss (15.67 t/ha) occurred from cultivated fallow plot and minimum runoff (70 mm i.e. 15% of rainfall) and soil loss (1.8 t/ha) was recorded from permanent vegetative of *Cenchrus ciliaris* grass plot. C values obtained were 0.26, 0.26, 0.27, 0.35, 0.35, 0.11 and 1.00 for

bajra + cowpea, bajra + mung, cowpea, mung, guar, C.ciliaris and cultivated fallow respectively.

McGregor and Mutchler (1983) studied C-factor for no till and reduced till corn. Cropping and management (C) values for use in the universal soil loss equation were derived by crop stage and annual periods for no-till corn grown for silage or grain, and for reduced-till corn for grain. The C-values as compared to those for conventional till corn for silage and grain reflected the soil erosion control benefits of no-till and reduced till corn. The C-values measured for all treatments were much lower than those previously accepted.

Alberts *et al.* (1985) conducted a study on corn and soybean cropping effects on soil losses and C-factors with the objectives to evaluate differences in soil and water losses between continuous corn and continuous soybean cropping for conventional, field cultivation and no-till methods of tillage and to evaluate differences between measured cropping and management factors and those in Agricultural Handbook 537, USDA that are currently used in soil conservation planning. Annual 'C' factors for soybean were about two times those of corn for all tillage methods. Measured 'C' factors for all tillage methods were consistently lower than those predicted in Agricultural Handbook 537 USAD.

Kramer and Alberts (1986) calculated the C factor for corn under changing management. The 'C' factor was derived from corn under changing management. The C-factor was derived from a 37 year record for precipitation, erosivity and soil loss from corn under study plots. The C-factor tended to decrease during the record period from the latter, more homogenous 24-years period, the annual

C-factor was 48 per cent less than that calculated from about the same to 85 per cent less than those values in Agril. Handbook, 537.

Gutal *et al.* (1988) conducted a study on effect of crop cover, stubbles, cultivation practices and land slopes on runoff and soil loss in 1985. The cropping management factor 'C' for greengram under simulation condition was found to be 0.26.

Hazari (1990) found that crop management factor for pearl millet is 0.61.

Patil and Bangal (1990) reported C-value for pearl millet as 0.47 in 1.5% slope, contour ridges with across the slope cultivation.

Verma *et al.* (1990) conducted runoff plot studies at the CSWCRTI Research Centre, Kota for five years (1981-82 to 1985-86) to evaluate the effect of different vegetative covers on erosion losses at 1 per cent slope. The average data showed the highest runoff (37%) and soil loss (3.96 t/ha) from cultivated fallow and lowest runoff and soil loss (7% and 0.21 t/ha, respectively) from *Dichanthium annulatum* grass plot. Contour cultivation of sorghum and sorghum + pigeon pea (1 : 1) recorded lower runoff and soil was and higher grain yield when compared with up and down cultivation. Cropping management factor 'C' of USLE remained 0.50 and 0.60 for sorghum and sorghum + pigeon pea (1 : 1) respectively.

Karad *et al.* (1991) evaluated 'C' factor in USLE for Parbhani. The 'C' factor was calculated on four crop stage periods. The 'C' factor of various crops worked out were intercropping of sorghum + pigeonpea (0.18), pigeonpea (0.23), soybean (0.31), cotton (Rohini) (0.32) and cotton (Purnima) (0.35).

Dhuruvanarayan (1993) gave values of crop management factor (C) for various vegetative covers at different location in India.

Crop management factor (C) for various vegetative covers at different location in India

Crop	Kota (Baroda)	Vasad	Kharagpur	Agra	Hyderabad	Rehmankhera (Lucknow)
Greengram	0.39	0.47	-	-	-	0.45
Blackgram	0.54	-	-	-	-	-
Groundnut	0.41	0.38	-	-	-	-
Groundnut + Arhar	-	-				0.42
Soybean	0.42	-	-	-	-	-
Cowpea	0.39	0.32	0.17		-	-
Guar	0.59	-	-	-	-	0.35
Guar + arhar	-	-	-	0.42	-	-
Maize	0.50	-	0.35		-	-
Jowar	0.62	-	-	-	-	-
Jowar+arhar	0.33	-	-	0.64	-	0.28
Red gram (Pigeonpea)	-	-	0.38	-	-	-
Jowar + Red gram	-	-	-	0.32	-	-
Paddy		0.28	-	-	-	-
Bajra	-	-	-	0.61	0.40	-
Castor	-	-	-	-	0.79	-
Til	-	-	-	0.51	-	-
Natural cover	0.14	-	-	-	-	0.39
Grass (*Cynodon dactylon*)	0.22	-	0.05	-	-	-
Grass (*Dichantium annulatum*)	0.01	-	-	0.13	-	-

Kurothe and Singh (1993) started an experiment to determine crop management factor of USLE for important crops in Vasad region. The 'C' factor for Tur, Bajra, Jowar, Jowar + Tur and Mung were found to be 0.47, 0.41, 0.40, 0.37 and 0.32, respectively.

Pratap Narain *et al.* (1994) conducted a study USLE parameters during 1986-91 at, Dehradun on 1.86 x 22.13 m runoff plots at 8 per cent slope The crop management factor 'C' factor for

cowpea was 0.31 and for mandna and jhingora was 0.17 and 0.18, respectively which is close to 'C' factor of grass species.

Sharma and Santraj (1994) initiated a study during 1990 to determine runoff, soil and nutrient losses under different vegetative coves and to workout cropping management factor 'C' of USLE. The 'C' factor for various crops/vegetative covers on 2% slope is given in following table.

Crop management factor 'C' for various crops/vegetative covers

Treatments	1994	Average
Cultivated fallow	-	-
Greengram	0.25	0.28
Pigeonpea	0.43	0.49
Sorghum	0.33	0.38
Sorghum + greengram	0.51	0.44
Sorghum + pigeonpea	0.44	0.40
Vetiver barrier	0.25	0.40
Dichanthium annulatum	0.01	0.04

Nalatwadmath and Ramamohanrao (1998) estimated 'C' factor for different crops. The crop factor 'C' was found to be 0.69, 0.60, 0.53 and 0.46 for jowar, safflower bengalgram and Dolichos lablab, respectively. In case of *C. ciliaris* grass, the value of 'C' factor

for pre-monsoon and monsoon season was worked out to a total of 0.053.

Sumphamit and Jarutanayaluk (1999) carried out a comparative study of soil and water losses from agroforestry practices with three main different land use treatments, i.e. control (bare and up and down slope ploughing), cash crop and forest plantation in the forest reserve area of Phu Wiang Watershed, Amphoe Phu Wiang, Changwat Khon Kaen. Observed soil and water losses during 1988 to 1992 were employed in the analysis. The average soil and crop management factor and (CP factor) for control, cash crop, agro-forestry and forest plantation was calculated is 0.34, 0.19, 0.15 and 0.01, respectively.

The lowest mean (1998) 'C' factor was worked out to be 0.01 for *Dichanthium annulatum* followed by sorghum + vetiver (0.11), cowpea (0.17), sunhemp (0.20), sorghum and soybean (0.28 each) and blackgram (0.32).

Nalatwadmath and RammohanrRao (2000) estimated 'C' factor of USLE for different crops as well as the influence of different vegetative covers on soil, water and nutrient loses. The 'C' factor in respect of *C. ciliaris* for the period June-August and September-October were worked out to be 0.086 and 0.043, respectively while for the year as a whole it was 0.13.

Sthool *et al.* (2001) conducted an experiment at Rahuri during *kharif* 1995 to determine crop management factor for *kharif* crops. The crop management factor for different crops are presented in Table 2. From table it is seen that crop management factor is maximum in peal millet (0.34) followed by red gram (0.30) and greengram (0.25).

From the various studies regarding the cropping management factor (C), it is cleared that erosion from a field is greatly influenced by density, kind of cover of crop and root growth, water use by growing plants and amount of prior residues in the ploughed layer. These conditions differ significantly within the period from planting to harvest of the crop. It is also affected by the distribution of erosive rains within a year. Considering these factors, Wischmeier and Smith (1978) subdivided the crop season into 6 growth periods. These 6 crop growth stage generally do not fit well in Indian conditions where the crop growing season is much shorter than the crop season on which the original crop stage have been defined. In India it may be quite sufficient to divide the 100-120 days crop growth period of *kharif* season into 3 or 4 uniform growth stage period. (Rao, 1981; Pratap Narain *et al.*, 1980).

In absence of crop-growth stage period data, average value of C of the crops have been determined for Hydrabad, Agra, Rehmankhera (Lucknow) and Dehradun based on total seasonal soil loss data (Gurmel Singh *et al.* 1981). Roose (1977) had also suggested calculation of 'C' value taking into account mean annual values of West Africa. Till now it would appear that 'C' values are available for only limited crops and stations under Indian conditions. Further work is going on in this direction and 'C' value for more crops and station may be available in near future.

2.4.2 Cropping management factor (C) suggested by RUSLE

The effect of cropping management is expressed in Revised Universal soil loss Equation (RUSLE) by the cover and management factor (C).

Wischemerier (1978) provided a guideline to the conservation planning for the prediction of rainfall erosion losses. Cover and management effect can not be independently evaluated because their combined effect influenced by many significant inter relations.

Murphree (1980) determined cover and management for cotton. They were derived using sediment yield data from a 15.6 ha watershed with 0.2 percent slopes. Cropstage C – values ranged from 0.10 for full cotton canopy to over 1.00 for the winter and bedding periods. The average annual C- value was 0.58, which reflects the highly erodible condition of land used. This research furnishes data – based values for the field user of the universal soil loss equation to used in deriving locational C – factors for cotton.

Mutchler (1982) studied a sub factor method for computing C factors, for continuous cotton. A system of sub factors for computing the C factor in the universal soil loss equation was proposed for cotton. These sub factors are multipliers that represent the effects of land use residual, incorporation residue, tillage intensity and recency, macroroughness, canopy and cover. Also shown is the need for assessing the variation of soil erodibility throughout the year because of the variation in soil water content.

Renard (1991) proposed Revised universal soil loss equation which contents four sub factors surface roughness (SR),

surface cover (SC), prior land use (PLU) and crop canopy (CC). To illustrate some of the differences between RUSLE and USLE soil loss estimate calculations were made for a continuous corn field with conventional tillage near Indianapolis, Indiana and for rangeland near Tombstone, Arizona.

Summary of RUSLE and USLE soil loss estimates for two locations.

Porter (1991) proposed a RUSLE MODEL and prepared a report on it. It contents a procedure to calculate all factors of RUSLE.

Knneth (1991) proposed some revisions and additions incorporated in USLE to result the RUSLE.

Tiwari (2000) evaluated Water Erosion Prediction Project (WEPP) and compared it with USLE and RUSLE. Sixteen hundred plot years of natural runoff plot data were used for verification and validation of WEPP, including most of data used to develop USLE. WEPP predictions of soil loss from natural runoff plots at 20 different locations were compared to measured data and existing technology (i.e. USLE and RUSLE). WEPP recorded a model efficiency of 0.71 compared to 0.80 to 0.72 for the USLE and RUSLE respectively. While the USLE and RUSLE did exhibit better model efficiency than WEPP this could be attributed to availability of more refined and site specific input parameters for the empirical models.

2.4.2.1 Prior Land Use Sub factor

Parker (1962) observed decomposition of cornstalk residue placed on the surface of soil or burried in the field. It was followed during a corn crop growing in season by removing from the soil at various times subsamples cloth bags. Decomposition during

the season (20 weeks) amounted to 50 percent of surface residue and 65% of burried residue. Half of this decomposition occurred in 8 weeks and in 5 weeks for surface and for burried residue respectively.

A maximum of 12 pound of N per 3 tons of residue per acre was immobilized by burried residue. This occurred after three weeks incubation. There after, total N content of the residue declined. A net loss of N occurred after a 5 weeks with no N fertilization and after 15 weeks with N fertilization. The C/N ratio declined from 57 to 22. The decline in C/N ratio, both with surface and burried residue, was caused by loss of carbon from the residue rather than on increase in total N.

Laflen (1981) studied the effect of crop residue on soil loss from continuous row cropping. A rainfall simulator was used to evaluate relative soil losses as affected by crop residue, for several combinations of crop rotations, tillage system and canopy at two locations of Iowa. Derived mulch factor crop residue relationships were apparently little affected to crop conopy, kind of residue or crop rotations but were different for the two locations. The locational difference in mulch factor crop residue, relationship were apparently due to differences in slopes and (or) soils and could be explained on the basis of sediment transport, sedimentation theory and size distribution of eroded material.

The results of this study indicated that present soil erosion prediction methods for conservation tillage system can be substantially improved by including the interaction effects of crop residue, soil and slope.

Gregory (1982) proposed, a study on soil cover prediction with various amounts and types of crop residue. An equation had been derived to predict the fraction of soil covered by crop residue as a function of mass of residue. The equation was checked with experimental data reported in the literature. A method of physically measuring the calibration coefficient in the equation was also checked. Coefficients for several types of crop residue were measured finally, the equation was verified and found to work for actual field conditions. The derived equation is relatively simple yet provides a fundamental theoretical basis on which residue management systems can be analysed.

Cogo (1984) observed soil loss reductions from conservation tillage practices. Soil loss reductions by residue cover (mulch) under field conditions were verified by deriving a mulch factor for no-till chisel plowing plus disking and spring sweep tillage using anchored and unanchored corn (Zea mays L.) and soybean (Glycine max L. Merr.) reduces on a 4.5% slope 10.5 m long on Russel silt loam soil. A mulch factor was also derived from sweep tillage using anchored wheat residue on a 6.5% slope Martinsville loam soil, for simulated slope lengths of 35, 65, 82, 110 and 135 m. Corn residue was more effective in reducing erosion than soybean residue and the residues partially incorporated into the soil loss than residues loose on the surface.

Gidey (1985) evaluate and predict residue decay. The decomposition of soybean, corn, sunflower and wheat residues was studied under field conditions. After 12 months exposure, residue mass losses were 74, 71, 61 and 36% for soybean, corn, sunflower and wheat residues, respectively. Temperature, moisture and the initial carbon/nitrogen ratio of the residue were important factors

that affected decomposition. The experimental data were also used to check and verify a theoretically derived residue decay model.

Brown (1989) studied rill erosion as affected by incorporated crop residue and seasonal consolidation. Cornstalk residue was incorporated at rates of 0, 1120, 2240 and 4480 kg/ha. An empirical factor was developed from the data to express the relative effect of incorporated crop residues on rill erosion. This factor was a decreasing exponential model with a decay coefficient value of 2.77×10^{-4}. An empirical factor was also identified to express the combined relative effects of prior erosion, lack of disturbance weathering and wetting and drying on rill erosion. This factor was a decreasing exponential model with a decay coefficient value of 0.046.

2.4.2.2 Crop Canopy sub factor (CC)

Quinn (1983) observed the characteristics of raindrop through fall under corn canopy. A laboratory rainfall simulator was used to study the raindrop size and velocity under a corn canopy. Drop sizes were measured by using a dye paper technique and drop velocities were measured photographically. Streamflow was calculated on the basis of rainfall under the conopy and incident rainfall above the canopy.

Upto 49% of incident rainfall appeared as streamflow. Drops that splashed from leaves were quite small and contained little kinetic energy. The ratio of kinetic energy at ground levels to kinetic energy at the top of the canopy was compared with the ratio predicted by Wischmeier and Smith (1978) for use in the Universql soil loss Equation. The comparison indicated little difference between what they observed and predicted.

2.4.2.3 Surface Roughness sub factor (SR)

Zobeck (1987) noted the effects of tillage and rainfall on random roughness. The study was a review and analysis of previous studies dealing with factors associated the formation of tillage induced (non-oriented) roughness of the soil surface. Tillage and rainfall had the greatest effect on random roughness. A model predicting changes in random roughness with changes in tillage and rainfall amount was proposed. Random roughness varied from 5.0 cm for a large offset disk operation to 0.07 cm for no – till systems and decreased exponentially with increasing rainfall. The proposed model, currently under development to predict the effects of wind and water erosion soil movement.

Sthool (2001) studied C factor. For that he took observations of plant height and crop canopy for different days. The cropping management factor for pearl millet, red gram and green gram were found.

Biometric observations in different treatments

Days after sowing	Pearl millet (T2)		Red gram (T3)		Green gram (T4)	
	Plant height (cm)	Crop canopy (%)	Plant height (cm)	Crop canopy (%)	Plant height (cm)	Crop canopy (%)
16	5	4	7	3	6	6
24	12	12	12	7	7	20
31	30	48	24	13	10	67
40	32	52	30	17	13	81
44	33	60	45	36	14	87
51	43	60	55	58	22	94
65	45	65	66	65	23	100
72	48	68	90	73	23	100
79	49	70	109	77	22	70
86	45	64	110	82	21	45
93	43	47	111	89	20	30
100	42	36	112	96	20	16

CHAPTER – III

METHODOLOGY

This chapter illustrates the materials used and methodology adopted for "Study on runoff factor and cropping management factor of soil loss equation at Akola.."

3.1 DATA COLLECTION

3.1.1 Experimental Site Location And Climate Condition

The Agro-ecology and Environment Centre located at Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) were selected as experimental site. The site is located between $20^0\ 41^1$ North latitude and $77^0\ 02^1$ East longitude. Akola district fall in assured rainfall zone of Maharashtra state having an average annual rainfall of 790 mm. Rainfall occurs mainly from south-west monsoon originating from Arabian sea. The mean monthly minimum and maximum temperature of experimental site is 20.5°C and 34.4 °C respectively with recorded minimum and maximum temperature of 11.8 °C and 48.5 °C in the month of December and May respectively.

3.1.2 Physico-Chemical Properties of Soil

3.1.2.1. Physico-chemical properties of soil at Agro-ecology and Environment Centre

The physico-chemical properties such as soil depth, bulk density, infiltration rate, organic carbon, etc for the seven experimental plots of Agro-ecology and Environment Center is presented in Table 3.1.

Soil of the experimental plot is shallow to moderately deep and having sandy loam texture. The infiltration rate ranges from 3.00 to 5.6 cm/hr.

Table 3.1 Physico-chemical properties of soil at Agro-ecology and Environment Centre

Sr. No	Particular	Treatment						
		T_1	T_2	T_3	T_4	T_5	T_6	T_7
1	Soil depth (cm)	20	20	20	76	81	83	80
2	Clay (%)	19.6	19.6	15.6	17.6	19.6	23.6	22.4
3	Silt (%)	8.0	9.4	9.0	13.8	13.8	11.4	10.6
4	Sand (%)	72.4	71.0	75.4	68.6	66.6	65.0	67.0
5	Depth class	Shallow	Shallow	Shallow	Mod. deep	Mod. Deep	Mod. Deep	Mod. deep
6	Textural class	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam
7	Bulk density (gm/cc)	1.38	1.34	1.31	1.27	1.22	1.25	1.25
8	Field capacity (%)	21.58	24.34	25.79	31.30	29.20	20.90	31.10
9	Permanent wilting point	10.15	12.20	13.50	16.10	15.30	15.10	16.70
10	Infiltration rate (cm/hr)	5.26	5.26	5.20	3.66	3.33	3.00	4.40
11	Freelime(%)	3.13	3.26	3.06	3.20	2.96	2.33	3.33
12	E.C. (dS/m)	0.13	0.15	0.15	0.18	0.16	0.16	0.26
13	PH	8.30	8.30	8.40	7.90	8.10	7.90	7.60
14	Organic carbon (g kg^{-1})	6.12	6.47	6.58	5.28	5.62	5.68	5.43

(Source : Anonymous, 2001)

3.1.2.2 Details of seven experimental plots of Agro-ecology and Environment Center

To estimate runoff factor and cropping management factor for seven experimental plots with different treatments, the data regarding peak runoff rate, runoff volume and soil loss were taken at AEEC. The contour map showing all topographic features of the AEEC Dr. PDKV Akola is presented in fig. 3.1.

The average main and lateral slope of different plots under study is 1.6 per cent and 0.7 per cent respectively. The location of experimental plots are shown in map and different treatment and area of experimental plots are given in Table 3.2

Table 3.2 : Different treatments and its area

Sr. No.	Treatments	Length (m)	Width (m)	Area (ha)
1.	T_1 - Sowing along the main slope	129.0	30.9	0.40
2.	T_2 - Contour cultivation along leucaena key hedge at 1m VI	126.9	28.0	0.35
3.	T_3 - Contour cultivation along vetiver key hedge at 1m VI	124.5	28.0	0.34
4.	T_4 - Sowing along the main slope	129.4	28.0	0.36
5.	T_5 - Contour cultivation along leucaena key hedge at 1m VI	126.9	28.0	0.35
6.	T_6 - Contour cultivation along vetiver key hedge at 1m VI	124.5	28.0	0.35
7.	T_7 – sowing along the graded bund	122.3	28.0	0.34

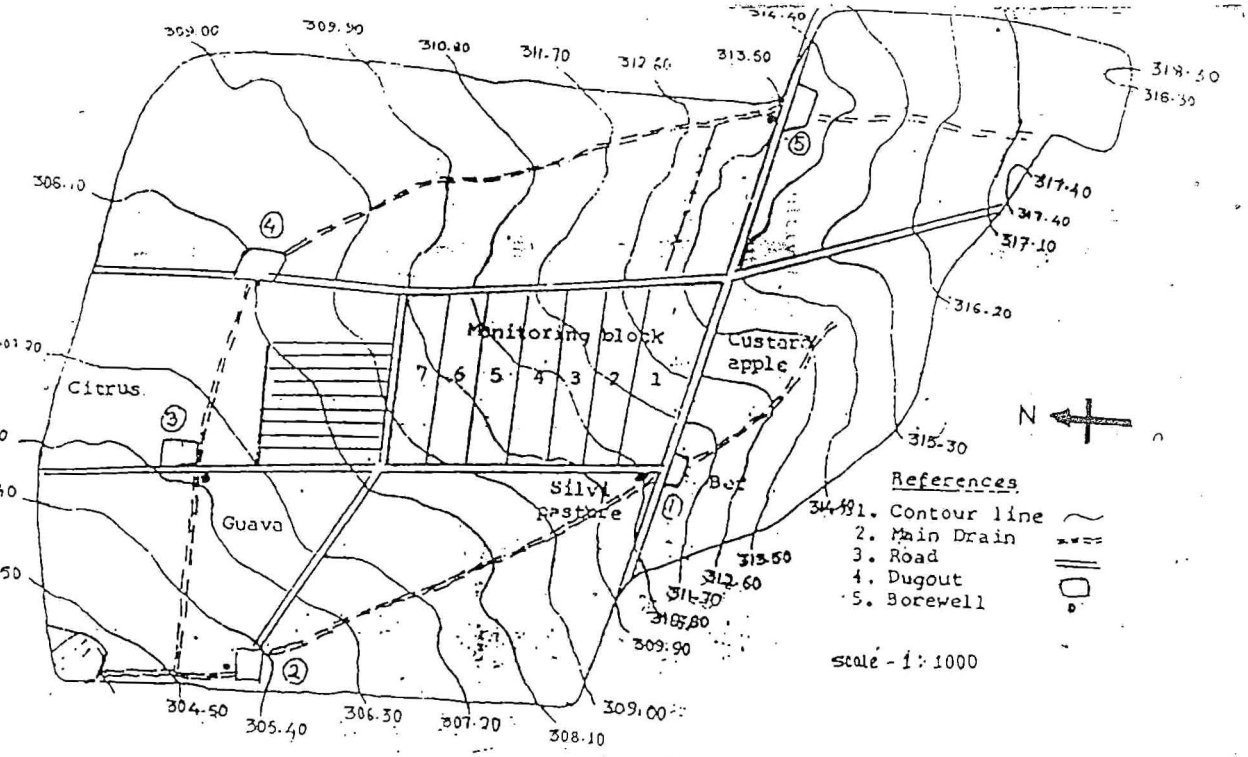

Fig. 3.1 TOPOGRAHIC MAP OF SEVEN EXPERIMENTAL PLOTS AT AGROECOLOGY AND ENVIORNMENT CENTRE DR. PDKV AKOLA

3.2 COLLECTION AND ANALYSIS OF DATA

3.2.1 Rainfall

Daily rainfall data of 14 years (1988-2001) recorded by recording rain gauge was collected to determine the erosion index.

The rainfall storm of 12.5 mm depth or more depth is used for estimation of the erosion index. An analysis for distribution of rainfall at different intensity classes was done. The 14 years (1988-2001) rainfall chart were analyzed for amount of rainfall received in different intensity classes, classified as 0-1, 1-2, 2-3, 3-4, 4-5 and above 5 cm/hr. The seasonal rainfall distribution under above classes were determined.

3.2.2 Peak runoff rate

Peak runoff rate of each runoff producing rainstorm was calculated from hyrdograph obtained from stage level recorder located at each experimental plot of AEEC Dr, PDKV, Akola.

The graph shows the guage-heights for different time intervals

3.2.3 Runoff volume

Clock driven, vertical drum daily type of stage level recorder was installed on 30 cm H-flume to measure runoff rate and runoff volume. Runoff depth is determined after analysis of hydrograph.

3.2.4 Calculation of Soil Loss

The surface runoff samples were collected at the time of runoff events flowing through 'H' flumes from each monitoring plot to

determine concentration of soil in runoff sample. Then, total soil loss from each runoff producing rainstorm is calculated from runoff volume.

3.3 THE UNIVERSAL SOIL LOSS EQUATION FOR ESTIMATING THE SOIL LOSS

$$A = RKLSCP \qquad \text{- - - - - - -} \quad (3.1)$$

Where,

A = The soil loss in t/ha/yr

R = The rainfall erosivity factor which is the number of rainfall erosion index units for particular location.

K = The soil erodibility factor which compares the actual erosion to that erosion from clean, tilled, fallowed, uniform slope of 9 % and length of 22.13 m.

L = The slope length factor is the ratio of soil loss from the field slope length to that from a 22.13 m length under identical conditions.

C = The cover and management factor is the ratio of soil loss from an area with specified cover and management to that from an identified area in tilled continuous fallow.

P = The support practice factor, is the ratio of soil loss with a support practice like contouring, strip cropping or terracing to that with straight row turning up and down the slope.

3.4 ESTIMATION OF VARIOUS PARAMETERS OF UNIVERSAL SOIL LOSS EQUATION

3.4.1 Rainfall Erosivity Factor

The rainfall erosivity factor (R) is the number of rainfall erosivity index units (EI_{30}) for a particular ratio.

The method suggested by Wischmeier (1959) was used for estimating the erosion index values of each storm. The EI_{30} is expressed as

$$EI_{30} = \frac{KE \times I_{30}}{100} \quad \text{---- (3.2)}$$

Where,

EI_{30} = Erosivity Index (metric units)

KE = Kinetic energy of storm (m-t/ha-cm).

I_{30} = Maximum 30 minute rainfall intensity for storm (cm/hr).

For computing kinetic energy of the storm, the equation proposed by Wischmeier and Mannering (1969) in metric units was used as

$$KE = 210.3 + 89 \log I \quad \text{------ (3.3)}$$

Where,

I = Rainfall intensity,cm/hr.

3.4.1.1 Runoff factor of MUSLE

Runoff factor of MUSLE was calculated using equation suggested by Duggal (2000).

$$S_y = 11.8 (Q\ qp)^{0.56} KLSCP \qquad \text{-----(3.4)}$$

Where,

S_y = Sediment yield, Tonnes

Q = Runoff volume, mm

qp = Peak runoff rate, lit/sec

K = Soil erodibility factor

S = Slope factor

C = Cover management factor

P = Conservation practice factor

3.4.2 Soil Erodibility Factor (K)

The soil erodibility factor is defined as average soil loss per unit of the erosion index (R) from continuous fallow on plot of 22.13 m length and 9 per cent slope.

A soil erodibility factor was found by using a convenient erodibility equation (Wischmeier *et al.*, 1971). Only five soil parameters viz., per cent of silt plus very fine sand, per cent of sand greater than 0.10 mm, organic matter content, structure code and permeability class were required for calculation of soil erodibility factor .

For soils containing less than 70 per cent silt and very fine sand, the soil erodibility factor K, can be computed from the equation.

$$100\ K = 2.1\ M^{1.14}\ (10^{-4})\ (12 - a) + 3.25\ (n - 2) + 2.5\ (c - 3) \qquad \text{- - - - (3.4)}$$

Where,

M = Particle size parameter

= (Per cent silt + very fine sand) "or"

= (100 - per cent clay)

a = Per cent organic matter

b = Soil structure code used in soil classification

c = Profile permeability class

Also the soil erodibility factor 'K' was determined with the help of recorded soil loss data.

3.4.3 Topographic Factor (LS)

The topographic factor (LS) as given by Wischmeier and Smith (1978) adjust the soil loss from the standard length of 22.13 m and 9 per cent slope. This factor was calculated from the following equation.

Length of slope factor

$$L = \left(\frac{\lambda}{22.13} \right)^{x} \qquad \text{- - - - - - - (3.6)}$$

Where,

x = constant

= 0.5 for slopes >4%

= 0.4 for slopes 4 %

= 0.3 for slopes <4 %

λ = slope length, m

Steepness of slope factor

$$S = \frac{0.43 + 0.30S + 0.043 S^2}{6.574} \quad \text{----------(3.7)}$$

Where,

S = field slope, %.

The field slope was measured from the point where the surface flow originates, usually from the top of the ridge to outlet of the runoff plots.

3.4.4. CROPPING MANAGEMENT FACTOR (C)

3.4.4.1 Cropping Management Factor (C) suggested by USLE

The cropping management factor (C) is the expected ratio of soil loss from land cropped under specified condition to soil loss from clean tilled fallow on identical soil and slope under the same rainfall, this item refers the combine effect of cover, crop sequence, productivity level, length of growing season, tillage practice, residue management and expected time distribution of erosive rain storm with respect of sowing and harvesting date in the locality.

There was no cultivated fallow treatment in the previous years. Due to non-availability of treatment cultivated fallow the cropping management factor was estimated from sowing along the

slope treatment plot from following equation in which P=1 and all other parameters of right hand side are known.

$$C = \frac{A}{RKLSP} \qquad \text{-------(3.8)}$$

Where,

A = soil loss (t/ha)

R = Rainfall erosivity factor (metric units)

K = Soil erodibility factor (t/ha/R)

LS = Topographic factor

Thus on the basis of the data available (at least three years),the 'C' factor of cotton and bajra crop for experimental plots at AEEC was estimated by using equation 3.8.

3.4.4.2 Cropping Management Factor (C) Suggested by RUSLE.

Cropping management factor (C)

Cropping management factor can be calculated from soil loss ratios i.e. SLrs with corresponding erosivity distributions i.e.R (Wischmeier and Smith 1978) These values are then summed and divided by the total erosivity (R_t) value for entire investigated time period.

$$C = \frac{SLr_1 (R_1) + SLr_2 (R_2) + \text{---} SLr_n (R_n)}{R_t} \qquad \text{----------(3.9)}$$

Where,

C = Average annual cropping management factor

SLr_1 = Soil loss ratio for given time period

R_1 = Fraction of the annual or crop EI occurring during that period

$_n$ = Number of period used in summation

R_t = Sum of erosivity index distributions for entire time period

Mutchler et al., (1982) soil loss ratios (SLrs) combines the effect of prior land use, crop canopy, surface cover, surface Roughness and soil moisture.

$$SLr = PLU\ SC.\ CC.\ SR.\ SM. \qquad \text{----------(3.10)}$$

Where,

SLr = Soil loss ratio for the given conditions.

PLU = Prior land use sub factor

SC = Surface cover sub factor

CC = Crop canopy sub factor

SR = Surface roughness sub factor

SM = Soil moisture sub factor

Prior Land Use Sub factor (PLU)

This sub factor expresses the influence on soil erosion of (1) prior cropping (2) dominant tillage practice (3) soil consolidation (4) time (5) biological activity. These components accounts for the residual effects of cropping. The prior land use relationship is expressed as :

$$PLU = DEN * (IV + RA * T) \times \exp(-5.3 \times 10^{-4} * RS) \quad \text{----------3.11)}$$

Where,

DEN = Surface density variable

IV = Initial value of a time decay function

RA= Rate of change of the effect of prior cropping per month

T = Time in months since a cropping change began

RS = Root mass in upper four inch of soil

The value of DEN for freshly tilled conditions is 1.0.

Porter (1998) suggested values for IV, RA and T are given in Table.3.3.

Table 3.3 Values of IV and RA as used in the prior land use subfactor for agricultural lands.

Land use	Period	IV	RA	T
Cropland or longterm range	All, except after oilseed or after	1	0	1
Pasture, or meadow	Meadow			
Cropland w/o meadow	After oilseed	1.4	-0.033	1
Cropland with meadow	After oilseed	0.91	0.0075	1
Cropland with meadow	Two years after meadow	0.3	0.33	1

Fig.3.2 represents years after period began of meadow, oil seed and other crops verses IV + RA(T), the value of IV + RA(T) can be found out from this figure for known land use practices.

RS is the mass of live roots and burried residue found in upper four inches of soil (lb ac^{-1} in^{-1}). It increase as days of planting after some days it become maximum and then constant. Porter (1991) recommended root mass in upper 4 inches of soil for corn, soybean cotton, sorghum winter and spring small grain are given in Table 3.4.

Table 3.4 : Recommended values of root mass (lb ac^{-1}) in upper four inch of soil (RS)

Days after planting	RS					
	Corn	Soybean	Cotton	Sorghum	Small grains	
					Winter	Spring
15	-	-	-	-	92	92
30	92	0	0	92	180	180
45	180	92	92	180	364	452
60	272	180	272	272	544	724
75	544	364	364	544	544	908
90	544	364	364	544	544	908
105	544	364	364	544	544	908
120	544	364	364	544	544	908

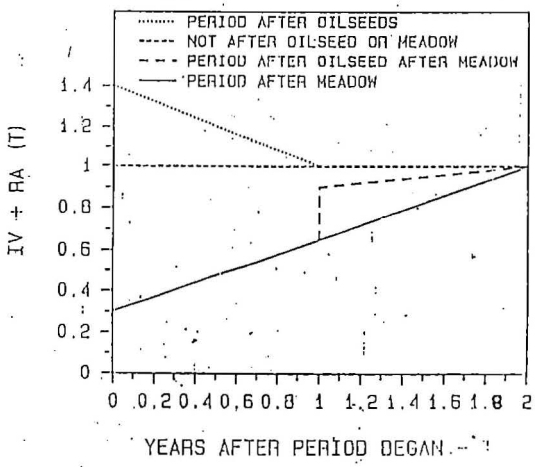

Fig : 3.2 Values of IV+R (T) for periods after meadow, oilseed and other crops.

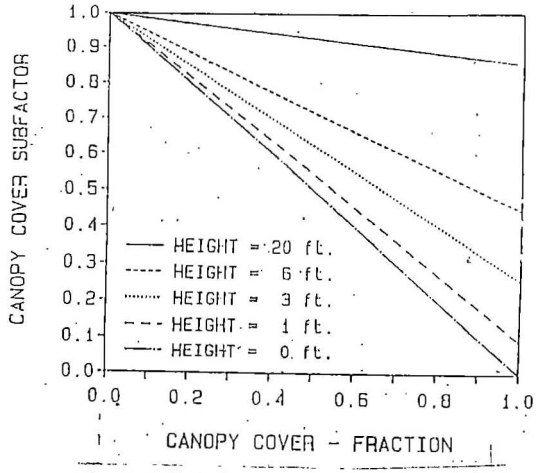

Fig : 3. 3 Effect of canopy cover and canopy height on the canopy cover sub factor

Surface Cover Sub factor (SC)

Surface cover affects erosion by reducing transport capacity of runoff water (Foster 1982), by causing deposition and by decreasing the surface area susceptible to raindrop impact.

It is perhaps the single most important factor in determining soil erosion. Surface cover includes crop residues, rocks, or other nonerodible material that is in direct contact with soil surface (Simanton et al., 1984, Box 1981, Meyer *et al.*, 1972).

The effect of surface cover on soil erosion is given by the following equation.

$$SC = \exp(-bM) \qquad \text{----------(3.12)}$$

Where,

b = Coefficient, 0.024

M= Per cent ground cover by canopy

Crop canopy sub factor (CC)

The crop canopy cover sub factor expresses the effect of vegetative canopy on reducing the rainfall energy impacting the soil surface.

The canopy cover effect is given by following equation

$$CC = 1 - FC \times \exp(-0.1 \times H) \qquad \text{--------(3.13)}$$

Where,

FC = Fraction of land surface covered by canopy.

H = Distance raindrops fall after striking the canopy (feet)

Effect of canopy cover to canopy cover sub factor for different height of crop was given graphically by Wischmeier and Smith (1978) and is shown in fig.3.3.

With the help of this graph we can find out canopy cover sub factor if we know canopy cover and height of plant.

Surface Roughness Sub factor (SR)

Surface roughness affect soil erosion. Cogo et al., (1984) showed that the random roughness i.e. RB, an index of surface roughness (Allmaras et al., 1966) can be used to predict soil erosion. These effects are given as.

$$SR = \exp(-0.026 \times RG) \quad \text{-----(3.14)}$$

Where,

SR = Surface roughness sub factor

RG = Surface roughness variable

Surface roughness variable (RG) can be calculated by

$$RG = \{ (25.4 \times RB - 6) (1- \exp (- 1.5 \times 10^{-3} \times RS))\} \times [\exp (-0.14 \times RN)] \quad \text{---------(3.15)}$$

Where,

RB = Random roughness in inch after a field operation

RN = Total rainfall (in) since last tillage

RS = Root mass in lb ac^{-1} in upper four inch of soil

Typical field operations and random roughness values suggested by Zobeck and Onstad (1987) are given below.

Table 3.5 Typical field operations and associated parameter values.

Field operations	Random roughness	Field operations	Random roughness
Blades(36"width)	0.5	Drill; semi-deep furrow	.45
Chisel(2"shovels)	.9	Fertilizer applicator	.5
Cult.,field (10-18 sweeps)	.6	Harrow (spike)	.3
Cult.,field (showels)	.7	Harrow (tine)	.4
Cult., row	.6	Lister	1
Disk; 1-way (18-24" disks)	1.1	Modboard (5-7" deep)	1.3
Disk; 1-way (24-26" disks)	1.2	Moldboard (8" deep)	1.9
Disk; large offset	2	Mulch treader	.6
Disk; tandem	.75	Planter; no-till	.4
Drill; conventional	.4	Planter; row	.4
Drill; no-till	.5	Planting; broadcas	.4
Drill; semi-deep furrow	.4	Rodweeder (plain)	.4
Sweeps (24-36")	.65	Rodweeder (shovel)	.45

Soil Moisture Sub factor (SM)

Antecedent soil moisture has a substantial influence on infiltration and runoff and hence on soil erosion. Fig. 3.4 represent the relationship between annual precipitation and replenishment. An annual precipitation increases, replenishment also increases and it becomes constant i. e. 1 when annual precipitation exceed more than 18"

Supporting Conservation Practice Factor (P)

The supporting conservation practice factor (P) is the ratio of soil loss with specified supporting conservation practice to corresponding soil loss with up and down cultivation.Data for calculating C factor were taken from sowing along the slope treatment on which supporting conservation practice is taken as 1.

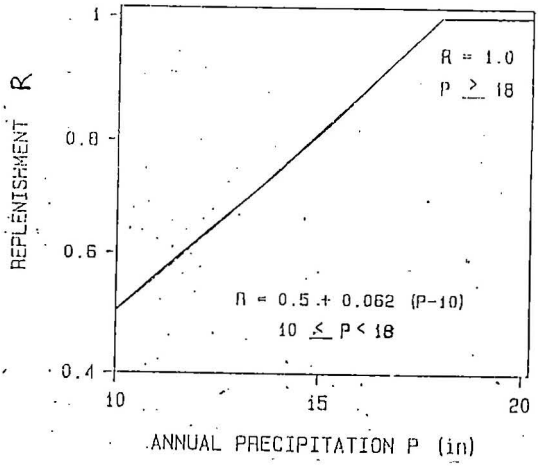

Fig : 3.4 Moisture replenishment rate versus annual precipitation.

CHAPTER - IV

RESULTS AND DISCUSSION

The study was conducted to estimate runoff factor of MUSLE and cropping management factor of USLE/RUSLE for commonly grown kharif crops at Akola.

4.1 DATA COLLECTION AND ANALYSIS

The experiment was conducted on Agro-ecology and Environment Centre at Dr. PDKV, Akola on seven experimental plots with four different treatments.

The details of data collected and its analysis is given below.

4.1.1 Storm wise Runoff and Soil Loss From Seven Plots of Agro- Ecology And Environment Centre

In order to estimate cropping management factor of commonly grown kharif crops in the experiment plots at AEEC, storm wise runoff causing rainstorm, erosivity, runoff and soil loss in different soil conservation treatments during 1989 to 2001 was collected and is tabulated in Appendix-A.

Runoff causing rainstorm varies from 8 mm for storm of date 18/06/93 to maximum 161 mm for the storm of date 20/06/97. The monthly runoff causing rainstorm ranged from zero to 265.5 mm (June, 90). The seasonal runoff causing rainstorm varied from 131 mm (1998) to 773 mm (1990).

In a rainy season runoff causing rainstorm occurs 3 to 14 times in a year with an average of 7.

In treatment T_1, maximum runoff of 75.70 mm was observed from a storm of 118 mm on 05/06/90.Monthly runoff in T_1 treatment varied from zero to 148.97 (June, 90) whereas seasonal

runoff ranged from 23.21 mm for year 1998 to 299.91 mm for the year, 1990.

Maximum soil loss from single storm was observed on 20/06/97 i.e. 2.98 t/ha. The monthly maximum soil loss of 3.59 t/ha was observed in June, 90 whereas maximum seasonal soil loss of 6.10 t/ha was observed in the year 1990.

Maximum runoff and soil loss was occurred in the treatment T_1 i.e. sowing along slope as there is no conservation measure adopted to it. Among the plots having conservation measures adopted, the maximum runoff and soil loss was observed from plot T_7 i.e. sowing along the graded bund. The trend of runoff and soil loss from various plots is as follows. Sowing along the Slope>sowing along graded bund > contour cultivation along leucaena key hedge > contour cultivation along vetivar hedge.

4.1.2 Details of Crop Grown in Different Experimental Plots of AEEC during 1990-2001

Crops grown under different plots for the year 1990-2001 are given in the Appendix –B.

4.2 DEPTH OF RAINFALL IN DIFFERENT INTENSITY CLASSES

The rainfalls of 14 years period (1988-2001) during different months of the rainy season were analyzed to classify the distribution of amount of rainfall on intensity basis.

The Table 4.1 reveals that, on an average maximum depth of rainfall (19.53 cm) occurs in the month of August followed by July (16.83 cm) and June (14.72 cm). From the total depth of rainfall (66.90 cm) of monsoon, on an average 44.52 per cent rainfall in below 1.0 cm/hr class, 28.03 per cent rainfall in 2 to 5 cm/hr class and 9.83 per cent in highest intensity class (above 5 cm/hr).

62.15 per cent rainfall occurs below 2 cm/hr intensity, which can be conserved and does not contribute effectively to soil loss. But the remaining 37.85 per cent rainfall depth which is received with intensity greater than 2 cm/hr, amount that 28.03 per cent moderately heavy rainfall intensity is between 2 to 5 cm/hr and remaining 9.82 per cent rainfall having high intensity, for this conservation planning is necessary because the risk of erosion at higher intensity is more.

Table 4.1 Average monthly rainfall depth (cm) in different intensity classes (cm/hr) during 1988-2001 at Akola

Month	Intensity Class (cm/hr)						Total
	Below 1	1-2	2-3	3-4	4-5	Above 5	Rainfall (cm)
June	5.86	1.67	2.25	1.44	1.62	1.88	14.72
July	9.20	3.11	1.29	0.93	0.88	1.42	16.83
Aug	10.31	4.17	1.75	0.82	0.97	1.51	19.53
Sep	2.80	1.82	1.40	1.37	1.09	1.19	9.67
October	1.62	1.03	0.88	0.78	1.27	0.57	6.15
Total	**29.79**	**11.80**	**7.57**	**5.34**	**5.83**	**6.57**	**66.90**
% of total	44.52	17.63	11.32	7.99	8.72	9.82	100
Cumulative (%)	**44.52**	**62.15**	**73.47**	**81.45**	**90.18**	**100**	-

4.3 RAINFALL EROSITIVITY INDEX

From the daily rainfall data of 14 years period (1988-2001) at CRS, Akola erosivity index were determined by using equation 3.2.The storms having depth greater than 12.5 mm were considered for the analysis according to Wischmeier and Smith (1978) and result of stage-wise erosivity index values (metric units) for the period 1988 to 2001 at CRS, Akola, is given in Appendix-C

whereas erosion index values of each runoff causing rainstorm are presented in Appendix-C.

From Appendix-B, it is observed that stage-wise erosivity index (R) varied from as low as zero to as high as 462.80 metric units(1988, stage-wise). It is seen that on an average 37.06 per cent erosion index is concentrated during stage I followed by 24.84 per cent, 23.44 per cent and 14.63 per cent of total seasonal erosivity index during stage III,II and IV respectively. Seasonal average erosivity index is 351.53.

4.4 RUNOFF FACTOR OF MUSLE

Stormwise peak runoff rate, runoff volume and soil loss for different treatment were collected /analysed for treatment T_1, T_2, T_3 from available seven years data. The runoff factor for treatment T_4 was not estimated, as sufficient data was not available for it. Using equation 3.4 the runoff factors were estimated .The results obtained are presented in Table 4.2.

From above table, it is observed that, peak runoff rate varies from 0.13 (02/08/92) to 13.20 (05/06/90), runoff volume varies from 0.17 (22/08/89) to 75.70 (05/06/90) and soil loss varies from 0.001 (22/08/89) to 4.08 (17/06/92) for treatment T_1,T_2 and T_3 respectively.

Runoff factor in all treatments T_1, T_2, and T_3 varies from 5.29 (18/06/93) to 455 56 (05/06/90), 5.83 (13/07/93) to 316.87 (18/08/89) 5.11(02/07/95 to 272.74(27/08/2000) for treatment T_1,T_2 and T_3 respectively.

Table 4.2. Estimation of runoff factor for treatment T_1, T_2 and T_3.

Date	Sowing along the main slope (T_1)				Contour cultivation along leucaena key hedge at 1 m VI (T_2)				Contour cultivation along vetiver key hedge at 1m VI (T_3)			
	Peak runoff rate (lit./sec)	Runoff volume (mm)	Soil loss (t/ha)	Runoff Factor	Peak runoff rate (lit./sec)	Runoff volume (mm)	Soil loss (t/ha)	Runoff factor	Peak runoff rate (lit./sec)	Runoff volume (mm)	Soil loss (t/ha)	Runoff factor
27/06/89	5	23.72	0.54	171.14	11.99	20.15	0.34	254.92	12.11	16.43	0.21	227.49
18/08/89	7.2	31.31	1.04	244.43	12	29.69	0.41	316.87	11	13.97	0.34	197.86
22/08/89	2.75	7.70	0.14	65.21	4.1	4.30	0.06	58.85	10.3	.017	0.001	16.14
19/09/89	1.15	6.40	.18	36.08	2.1	2.19	0.04	27.73	9	0.46	0.004	26.14
Total			**1.90**	**503.29**			**0.89**	**658.37**			**0.56**	**467.63**
05/06/90	9	75.70	1.43	455.56	13.20	58.20	0.77	487.25	13	45.70	0.37	421.93
18/06/90	2.7	20.28	0.49	111.02	4.13	11.34	0.21	101.71	4	5.50	0.11	66.62
19/06/90	2.8	21.96	0.74	118.46	6.00	15.50	0.41	149.35	5	13.32	0.20	123.88
21/06/90	2.4	31.03	0.93	126.88	8.3	24.87	0.44	233.42	6	20.68	0.27	175.53
24/07/90	1.3	17.91	0.7	68.77	3.77	10.58	0.08	92.97	3.21	9.38	0.04	79.42
25/07/90	4	65.41	0.75	266.56	9.49	41.53	0.34	335.30	9	32.72	0.24	284.80
08/08/90	0.71	7.89	0.11	30.90	2.1	4.68	0.05	42.42	3.7	4.03	0.04	53.58
09/08/90	0.98	8.94	0.13	42.21	2.12	8.73	0.12	60.47	5.83	6.94	0.08	93.71
12/08/90	0.77	2.16	0.04	15.68	-	0.25	-	-	-	-	-	-
16/08/90	1.4	22.75	0.70	81.96	5	11.36	0.29	113.32	8.3	9.89	0.21	139.27
17/08/90	0.231	3.26	0.03	11.8	0.321	2.81	0.02	11.13	1.99	2.07	0.02	26.07
31/08/90	0.31	4.96	0.11	15.01	3	2.57	0.05	37.03	3.0	2.36	0.04	26.43
02/10/90	0.98	12.98	0.40	49.02	1.73	4.12	0.11	35.44	6.01	6.29	0.15	-
08/10/90	0.3	3.68	0.07	12.47	0.37	0.95	0.01	6.57	2.3	0.48	0.005	12.47
Total			**6.10**	**1406.63**			**2.90**	**1706.38**			**1.70**	**1503.71**
17/06/92	1.3	15.11	4.08	62.52	4.2	12.06	2.13	106.28	6.3	8.82	0.33	111.93
19/06/92	1	10.2	2.1	43.36	1.1	7.11	1.9	37.33	3.10	3.2	0.09	42.65
02/08/92	0.32	2.23	1.3	9.67	0.136	5.4	0.7	9.92	0.98	1.5	0.01	14.64
08/08/92	0.98	10.7	0.24	43.99	1.99	6.1	0.11	47.75	3.2	3.3	0.06	44.17

21/08/92	2	20.0	1.29	93.11	3.3	11.57	0.24	90.72	2.14	4.21	0.1	40.41
01/09/92	0.841	11.33	0.21	41.70	1.1	9.2	0.89	43.13	3.30	6.9	0.18	67.92
07/09/92	3.2	39.69	0.67	177.83	7	18.05	1.3	177.32	6.99	15.87	0.4	164.85
Total			**5.90**	**472.27**			**5.01**	**512.45**			**2.10**	**468.57**
712/06/93	3.21	21.63	1.02	126.81	10.41	7.84	0.35	138.82	8	7.85	0.35	119.87
14/06/93	1.1	16.09	0.43	58.98	10.59	14.13	0.34	194.94	10	14.13	0.34	187.78
18/06/93	0.21	1.14	0.02	5.29	-	-	-	-	-	-	-	-
26/06/93	0.27	1.30	0.02	6.56	0.99	0.96	0.01	11.46	0.2	0.96	0.01	4.68
02/07/93	0.674	3.37	0.04	18.68	0.32	1.42	0.01	7.58	0.3	0.75	0.01	5.11
10/07/93	1.17	10.48	0.15	48.02	5.85	6.21	0.09	22.23	2.30	2.11	0.03	28.57
11/07/93	0.21	2.89	0.04	8.92	-	-	-	-	0.120	-	-	-
17/07/93	1.30	2.47	0.03	22.67	0.226	1.26	0.01	5.83	0.98	0.34	0.005	6.37
15/07/93	0.987	8.40	0.10	38.57	3.84	5.32	0.07	63.91	0.82	0.62	0.007	8.11
31/08/93	0.98	10.61	0.20	87.30	1.81	3.01	0.03	30.99	2	0.88	0.01	16.19
01/09/93	1	10.12	0.19	43.13	2.40	3.94	0.04	41.52	2.20	2.91	0.03	33.37
13/10/93	1.41	15.12	0.38	65.46	4.94	7.50	0.18	70.60	2.14	2.38	0.05	29.36
Total			**2.65**	**530.39**			**1.19**	**647.88**			**1.15**	**440.41**
30/07/98	3.2	11.82	0.43	90.24	6.89	6.35	0.18	97.91	12.01	5.67	0.14	125.44
22/09/98	3.1	7.79	0.19	70.19	6.27	4.96	0.10	80.87	12.00	4.32	0.09	107.68
02/10/98	3.2	12.27	0.73	92.15	6.99	7.61	0.30	109.23	12.2	6.46	0.25	136.14
Total			**1.35**	**275.35**			**0.58**	**288.01**			**0.48**	**369.25**
19/06/99	4	4.32	0.27	58.19	5.42	2.72	0.13	53.24	2.20	2.18	0.09	28.39
03/08/99	7.5	25.05	0.22	221.43	8	18.03	0.08	172.46	10.98	14.81	0.06	204.23
12/09/99	7	17.87	0.76	153	11	9.19	0.46	156.50	10.11	7.73	0.32	135.49
25/09/99	-	12.34	0.54	-	7	7.43	0.24	107.86	8.19	5.28	0.16	97.27
09/10/99	5	6.46	0.16	79.55	4	4.87	0.11	62.23	4.01	4.12	0.08	56.75
Total			**2.20**	**512.17**			**1.02**	**552.29**			**0.71**	**222.13**
09/07/00	6.5	24.13	0.094	200.14	13.1	15.89	0.50	234.52	13	14.30	0.38	220.12
27/08/00	8	42.24	2.25	360.62	13	22.69	0.89	285.07	13.2	20.65	0.72	272.74
29/08/00	6	7.70	0.16	100.94	13.1	4.52	0.08	115.99	13	4.08	0.06	109.05
Total			**3.35**	**608.70**			**1.47**	**635.58**			**1.16**	**601.91**
Average				**528.58**				**635.62**				**581.94**

Summation of seasonal runoff factor is maximum in all the treatment during 1990 and it is 1460.63, 1706.38, 1503.71 in treatment T_1,T_2 and T_3 respectively.

Maximum value for total amount of runoff factor shows the 1406.63, 1706.38, 1503.71 for the treatment T_1,T_2 and T_3 respectively during the year 1990.

Also the minimum seasonal runoff factor occurred as 232.58, 228.01 and 369.25 for the treatment T_1,T_2 and T_3 respectively during the year 1998.

Average runoff factor for T_1,T_2 and T_3 were found to be 528.58, 635.62 and 581.94 runoff factor is always more in treatment T_2 as compared to other two treatment except during 98.

From the table, it is observed that,as peak runoff rate and runoff volume increase, the runoff factor also increases.

4.4.1 EFFECT OF CUMULATIVE RUNOFF FACTOR ON CUMULATIVE SOIL LOSS

4.4.1.1 Effect of Cumulative Runoff Factor on Cumulative Soil Loss For Treatment T_1.

Annual estimated runoff factor and soil loss were taken from Table 4.2 and cumulative runoff factor and cumulative soil loss were calculated and presented in Table 4.3 to find the effect of between cumulative runoff factor on cumulative soil loss.

Summation of seasonal runoff factor is maximum in all the treatment during 1990 and it is 1460.63, 1706.38, 1503.71 in treatment T_1,T_2 and T_3 respectively.

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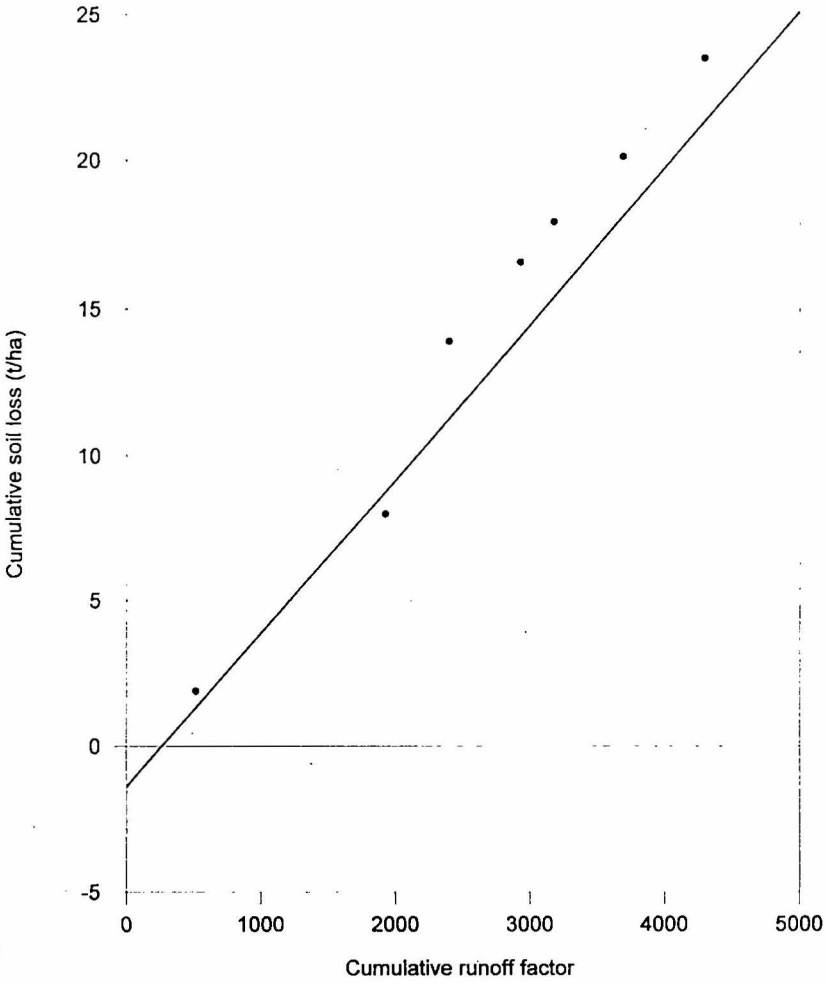

Fig. 4.1 : Effect of cumulative runoff factor on cumulative soil loss for treatment T_1

Table 4.3 : Effect of cumulative runoff factor on cumulative soil loss for treatment T_1.

Year	Runoff factor	Cumulative runoff factor	Soil loss (t/ha)	Cumulative soil loss (t/ha)
1989	516.86	516.86	1.90	1.90
1990	1406.63	1923.49	6.10	8.00
1992	472.27	2395.76	5.90	13.90
1993	530.39	2926.16	2.65	16.55
1998	252.58	3178.73	1.35	17.9
1999	512.17	3690.9	2.20	20.1
2000	608.70	4299.6	3.35	23.45
Mean		2704.49		14.54
SD		1151.54		6.85
CV		42.57		47.11

Runoff factor varies from 252.58 (98) to 1406.63 (90) and soil loss varies from 1.90 (89) to 5.90 (92) in treatment T_1.

Calculated mean form cumulative runoff factor and cumulative soil loss were 2704.49 and 14.54 respectively.

The figure (4.1) shows the effect of cumulative runoff factor on cumulative soil by a straight line. Relationship between cumulative runoff factor and cumulative soil loss is observed to be linear. The linear equation is as below.

$Y = -1.39 + 5.8 \times 10^{-3} X$ ----- (4.1)

$a = -1.3$ and $b = 5.8 \times 10^{-3}$

X = Cumulative runoff factor

Y = Cumulative soil loss

$R^2 = 0.98$ indicates that the relationship between X and Y is 98.07 percent liable. Thus the equation is best fit.

If runoff factor is increased by an amount of 1000 units the cumulative soil loss of 5.8 t/ha is expected. By using this eqn (4.1) if we put any value of X,we can find out the corresponding value for Y.

4.4.1.2 Effect of Cumulative Runoff Factor on Cumulative Soil Loss For Treatment T_2.

The value for cumulative runoff factor and cumulative soil loss were estimated and presented in Table 4.4.

In case of treatment T_2, runoff factor is maximum i.e. 1706.38 during 1990 and minimum i.e. 288.01 during 1988.Soil loss value was maximum i.e. 5.01 during 1992 and minimum i.e. 0.58 during 1998.

Calculated mean, SD and CV for cumulating runoff are found to be 3220.26, 1337.66 and 41.11 respectively soil loss respectively.

Table 4.4 : Effect of cumulative runoff factor on cumulative soil loss for treatment T_2.

Year	Runoff factor	Cumulative runoff factor	Soil loss (t/ha)	Cumulative soil loss (t/ha)
1989	658.37	658.37	0.89	0.89
1990	1706.38	2364.75	2.90	3.79
1992	512.45	2877.2	5.01	8.8
1993	647.88	3525.08	1.19	9.99
1998	288.01	3813.09	0.58	10.57
1999	552.29	4365.38	1.02	11.59
2000	635.58	5000.96	1.47	13.06
Mean		3229.23		0.38
SD		1327.66		4.08
CV		41.11		48.74

The fig.4.2 shows effect of cumulative runoff factor on cumulative soil loss by straight line equation. It is observed to be linear and the equation is

$$Y = -1.24 + 2.9 \times 10^{-3} X \text{ --- (4.2)}$$

$a = -1.24$ and $b = 2.9 \times 10^{-3}$

X = Cumulative runoff factor

Y = Cumulative soil loss

$R^2 = 0.93$ indicates that the relationship between X and Y is 93.70 percent liable. Thus equation is best fit. If runoff factor

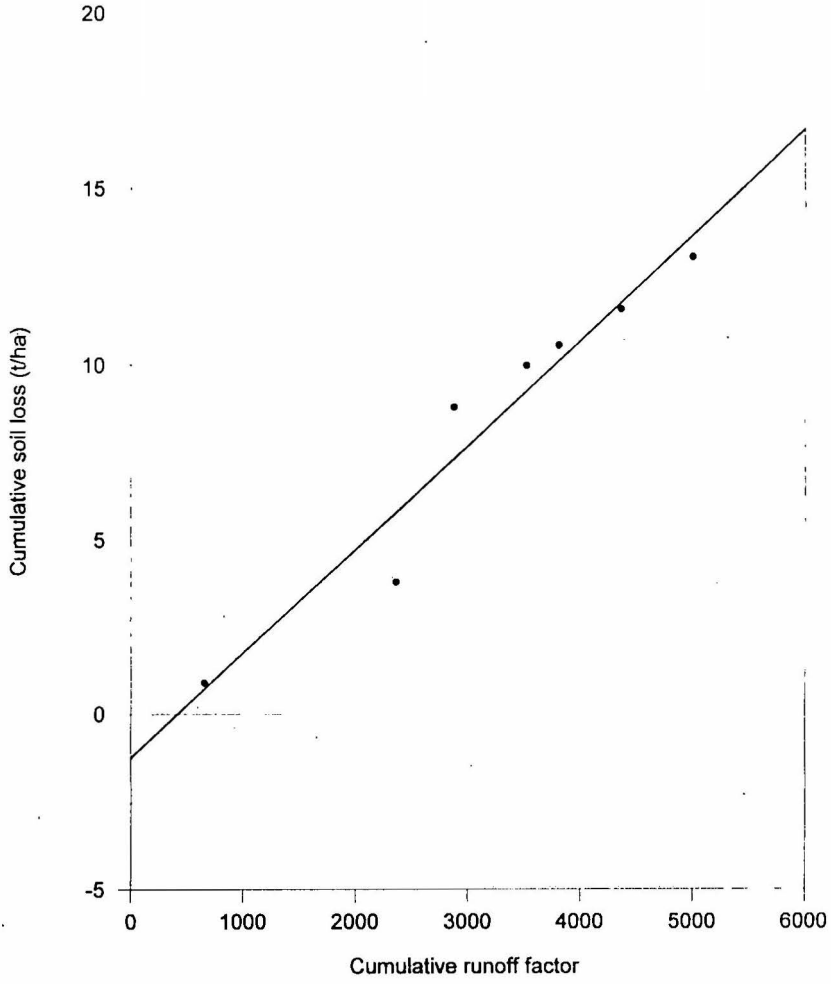

Fig. 4.2 : Effect of cumulative runoff factor on cumulative soil loss for treatment T_2

increased by an amount of 1000 units, the cumulative soil loss of 2.9 t/ha is expected.

By putting any value of X we can find out the corresponding value of Y by using above eqn 4.2.

4.4.1.4 Effect of Cumulative Runoff Factor on Cumulative Soil Loss For Treatment T_3.

Runoff factor were calculated with the help of equation 3.4 and presented in the following Table 4.5. The respective values for soil loss are also presented.

Table 4.5 : Effect of cumulative runoff factor on cumulative soil loss for treatment T_3.

Year	Runoff factor	Cumulative runoff factor	Soil loss (t/ha)	Cumulative soil loss (t/ha)
1989	467.63	467.63	0.56	0.56
1990	1503.71	1971.34	1.70	2.26
1992	486.57	2451.91	2.10	4.36
1993	647.88	3105.79	1.15	5.51
1998	369.25	3475.04	0.48	5.59
1999	522.13	3997.17	0.71	6.70
2000	601.91	4599.08	1.16	7.83
Mean		2866.85		4.69
SD		1278.14		2.34
CV		44.58		50.08

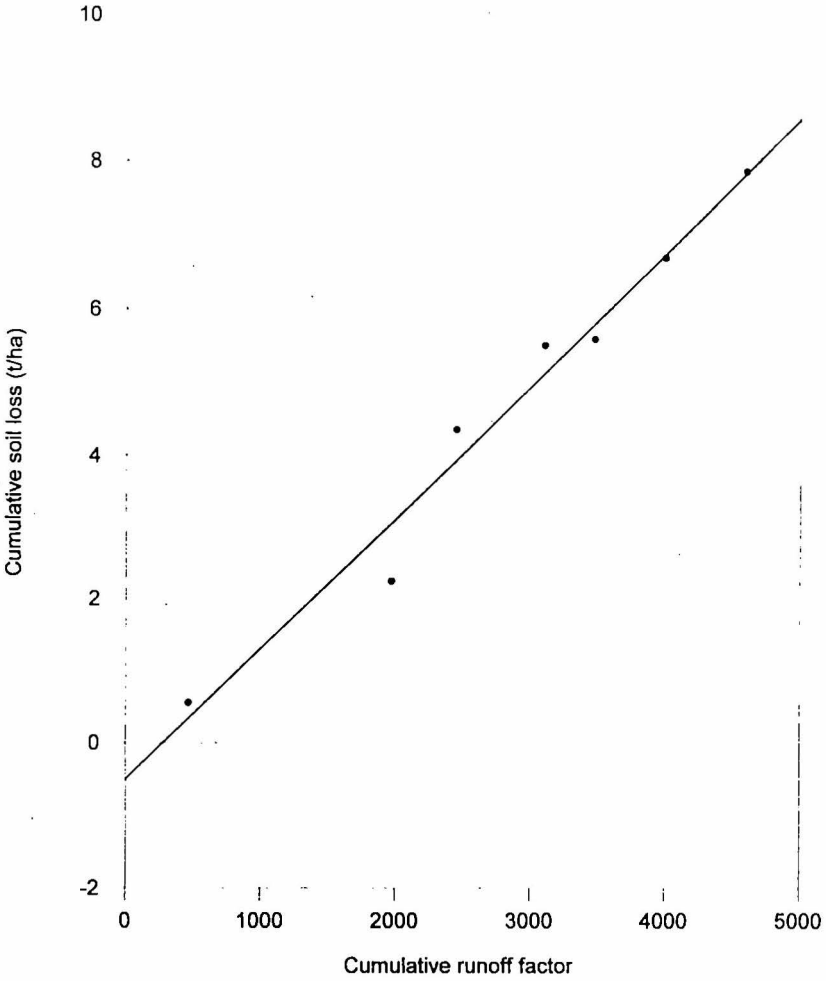

Fig. 4.3 : Effect of cumulative runoff factor on cumulative soil loss for treatment T_3

During 1990, the runoff factor is maximum i.e. 1503.71 and minimum i.e. 467.63 during 1992.

Maximum soil loss occurred i.e. 2.10 during 1992 and minimum i.e. 0.48 during 1998.

Calculated mean, SD and CV for cumulative runoff factor are 2866.85, 1278.14 and 44.58 respectively wherever 4.69, 2.34 and 50.08 for cumulative soil loss respectively.

The effect of cumulative runoff factor on cumulative soil loss is found to be linear and shown by following fig 4.3 .

$Y = -0.50 + 8.81x10^{-3} x$ -----[4.3]

$a = -0.50$ and $b = 8.81x10^{-3}$

X = Cumulative runoff factor

Y = Cumulative soil loss (t/ha)

$R^2 = 0.97$ indicates that relationship between X and Y is liable 97.23 percent i.e. The equation is best fit. If runoff factor is increased by an amount of 1000 units, the cumulative soil loss of 1.81 t/ha is expected.

By using above equation 4.3 if we put value of X, we can find out corresponding value for Y.

4.5 SEASONAL RAINFALL, RUNOFF CAUSING RAINSTORM, RUNOFF DURING COTTON GROWING PERIOD FOR TREATMENT SOWING ALONG THE SLOPE

Seasonal rainfall, runoff causing rainstorm, runoff, ratio of runoff causing rainstorm to rainfall and runoff to rainfall in per cent are given in Table 4.6.

Table 4.6 Seasonal rainfall, runoff causing rainstorm, runoff for cotton crop at AEEC, during 1993-2001 (except, 94)

Sr. No.	Season	Rainfall (mm)	Runoff causing rainstorm (mm)	Runoff (mm)	Runoff causing rainstorm/rainfall in per cent	Runoff/ rainfall in per cent
1	Seasonal -1993	741.1	383.0	103.62	51.6	13.9
2	Seasonal-1995	859.5	121.0	66.21	14.0	7.7
3	Seasonal-1996	695.5	301.6	61.61	43.3	8.8
4	Seasonal-1997	576.2	67.2	61.72	11.6	10.71
5	Seasonal-1999	1062.0	252.1	71.30	23.7	6.7
6	Seasonal -2000	545.4	172.0	69.24	69	27
7	Seasonal -2001	607.5	261.6	70.7	68	18
	Seasonal average	727.62	211.18	67.03	37.37	11.98

Seasonal rainfall varied from 545.4 mm for 2000 to 1062 mm for 1999. Seasonal runoff causing rainstorm, runoff varied from 67.2 mm (1997) to 383 mm (1993), 31.88mm (1998) to 103.62 mm (1993) respectively. Seasonal ratio of runoff causing rainstorm to rainfall and runoff to rainfall varied from 11.6 per cent (1997) to 69 per cent (2000) and 4.3 per cent (1998) to 27 per cent (2000) respectively.

The seasonal averages are found to be 662.17,211.18,67.03,37.37, 11.98 for rainfall, runoff causing rainstorm, runoff, runoff causing rainstorm/rainfall in per cent, runoff / rainfall in per cent respectively.

4.6 MONTHLY RAINFALL, RUNOFF CAUSING RAINSTORM, RUNOFF DURING BAJRA GROWING PERIOD FOR TREATMENT SOWING ALONG THE SLOPE

From Table 4.7, it is observed that the monthly rainfall varies from zero to 351.0 mm for month of Oct.-89 and June-90 respectively, whereas runoff causing rainstorm varied from zero to 265.50 mm (June, 90). The ratio of runoff causing rainstorm to rainfall and runoff to rainfall varied from zero to 41.19 per cent (Sept.-2001) respectively.

Seasonal runoff causing rainstorm, runoff varied from 172.08 mm (2000) to 773.0 mm (90), 69.13 mm (89) to 299.91mm (90) respectively.

Seasonal ratio of runoff causing rainstorm to rainfall and runoff to rainfall varied from 23.73 per cent (99) to 90.14 per cent (90) and 2.23 per cent (99) to 29.82 per cent (2000), respectively.

The average monthly rainfall varied from 85.67 mm for month of September to 229.9 mm for the month of August, whereas, the seasonal average rainfall for the period of study was 705.64 mm. The average monthly runoff causing rainstorm and runoff ranged from 49.40 mm to 124.59 mm whereas, the seasonal average runoff causing rainstorm and runoff during the study period was 340.71 and 118.16m, respectively.

Table 4.7 Monthly rainfall, runoff causing rainstorm, runoff for bajra crop at AEEC

Sr .No.	Year and Month	Rainfall (mm)	Runoff causing rainstorm (mm)	Runoff (mm)	Runoff causing rainstorm/rainfall in per cent	Runoff/ rainfall in per cent
1	June-89	183.0	51.50	23.72	28.14	15.37
2	July-89	30.5	-	-	-	-
3	August-89	184.3	135.40	39.01	73.46	21.16
4	September-89	58.0	58.00	6.40	100.00	11.03
5	October-89	-	-	-	-	-
	Seasonal	**455.8**	**244.90**	**69.13**	**53.72**	**11.78**
6	June-90	351.0	265.50	148.97	75.62	21.54
7	July-90	322.5	203.00	83.32	62.94	19.51
8	August-90	274.5	216.50	50.96	78.87	28.73
9	September-90	15.0	-	-	-	-
10	October-90	169.0	88.0	16.60	52.07	30.81
	Seasonal	**857.5**	**773.0**	**299.91**	**90.14**	**10.51**
11	June-99	287.7	95.50	8.13	33.19	11.53
12	July-99	144.7	-	-	-	-
13	August-99	294.9	48.50	25.05	16.44	5.57
14	September-99	202.7	79.10	37.44	39.02	19.25
15	October-99	132.0	29.00	6.04	21.96	16.63
	Seasonal	**1062.0**	**252.10**	**76.66**	**23.73**	**2.23**
16	June – 2000	81.4	74.3	24.13	91.27	29.64
17	August –2000	166.1	98.0	49.94	59.00	30.06
	Seasonal	545.4	172.0	74.07	69.49	29.92
18	June – 2001	195.1	114.5	29.7	58.68	15.22
19	Sept – 2001	67.2	60.5	27.6	90.29	41.19
20	Oct – 2001	119.8	86.6	13.8	72.28	11.51
	Seasonal	**607.5**	**261.6**	**71.1**	**68.49**	**18.61**
			Average			
21	June	219.64	120.26	46.88	57.19	18.48
22	July	165.9	67.66	27.77	20.98	6.50
23	August	229.9	124.59	41.21	56.94	21.36
24	September	85.67	49.4	6.9	57.25	17.06
25	October	105.17	50.9	9.10	36.50	14.60
	Seasonal	**705.64**	**340.75**	**118.16**	**59.47**	**20.65**

4.7 SOIL ERODIBILITY FACTOR (K) FOR SEVEN EXPERIMENTAL PLOTS AT AGRO-ECOLOGY AND ENVIRONMENT CENTRE

Soils of seven experimental plots were taken by Jami (1998), for estimation of soil erodibility factor. The soil erodibility factor 'K' of the soils were determined using soil erodibility nomograph of Wischmeier *et al.* (1971) and is given in Table 4.9.

4.8 TOPOGRAPHIC FACTOR (LS)

The topographic factor (LS) as given by Wischmeier and Smith (1978) to adjust the soil loss for known length of slope and steepness from the standard length of 22.13 m and 9 per cent slope. The 'L' factor was calculated by using equation 3.6 and 'S' factor by using equation 3.7.

The 'L' and 'S' factors for experimental plots are given in Table 4.8,

Table 4.8 : K, L, S factors for experimental plots at AEEC

Sr. No.	Treatment	K	L	S
1.	T_1 - Sowing along the slope	0.048	1.69	0.155
2.	T_2 - Contour cultivation along leucaena hedge at 1m VI	0.027	1.68	0.155
3.	T_3 - Contour cultivation along vetiver hedge at 1m VI	0.015	1.67	0.155
4.	T_4 - Sowing along the slope	0.003	1.70	0.155
5.	T_5 - Contour cultivation along leucaena hedge at 1m VI	0.022	1.68	0.155
6.	T_6 - Contour cultivation along Vetiver hedge at 1m VI	0.012	1.67	0.155
7.	T_7 - Sowing along the graded bund (0.2% grade)	0.023	1.66	0.155

4.9 CROPPING MANAGEMENT FACTOR OF USLE FOR DIFFERENT CROPS AT AGRO-ECOLOGY AND ENVIRONMENT CENTRE

4.9.1 Cropping Management Factor For Cotton Crop

4.9.1.1 Storm wise 'C' factor for cotton crop

The cotton crop was grown at AEEC during 1993 to 2001 (except, 1994).

On the basis of storm wise soil loss data available in sowing along the slope treatment i.e. T_1 or T_4 at AEEC, storm wise cropping management factor was estimated using equation 3.8 and is given in Table 4.9. The treatment sowing along the slope was control for supporting conservation practice so the value of 'P' factor is taken as one for this treatment.

From Table 4.9 it is observed that, the runoff causing rainstorm varies from 15.2 mm for the storm of 01/02/97 to 120.0 mm for the storm of 06/09/96.

The value of daily rainfall erosivity index 'R' ranged from 6.14 metric units (20/07/95) to 351.0 metric units (06/09/96). The cotton crop was sown on two plots i.e. T_1 and T_4 during alternate years therefore product of soil erodibility factor, length of slope and steepness of slope factor for plot one i.e. T_1 (0.048 x 1.69 x 0.154) is 0.0125 and for plot two (0.033 x 1.7 x 0.155) is 0.008.

The storm wise cropping management factor was estimated considering crop growing period. It is observed that, the values of cropping management factor varied from 0.10 to 2.17. As 'C' factor value above one is not feasible for cropped field thus ignoring the storms, having value above one, 'C' value varied from 0.10 to 0.87. It is observed that there is no correlation between 'C' values with the crop growing period. Yearly storm wise weighted mean of 'C' values estimated ignoring unfeasible values and it ranged

from 0.29 for year 1999 to 0.61 for the year 2000. Average of weighted mean of cropping management factor estimated from all the storms during experimental year came to be 0.43. The sample calculation for finding out the weighted mean of 'C' factor is given in Appendix-D. In all, storm wise calculation of 'C' values does not given any significant conclusion or usefulness for estimation of soil loss in universal soil loss equation.

Table 4.9 : Storm wise cropping management factor for cotton crop during 1993-2001 (Except-94)

Date	Runoff causing rainstorm (mm)	R Metric units	Sowing along the slope treatment T_1 or T_4		
			A (t/ha)	KLS	C
12/06/93	37.5	37.80	1.02	0.0125	2.17*
14/06/93	39.0	40.16	0.43	0.0125	0.87
02/07/93	18.5	4.58	0.04	0.0125	0.76
10/07/93	46.0	47.23	0.15	0.0125	0.25
13/07/93	57.0	38.20	0.03	0.0125	0.10
15/07/93	69.0	33.15	0.10	0.0125	0.24
31/08/93	39.0	35.50	0.20	0.0125	0.46
01/09/93	25.0	21.18	0.19	0.0125	0.74
13/10/93	24.0	14.70	0.38	0.0125	2.10*
Weighted mean					**0.42**
14/07/95	55.0	102.0	0.41	0.008	0.32
20/07/95	23.0	6.14	-	0.008	-
02/09/95	43.0	13.08	0.27	0.008	2.58*
Weighted mean					**0.32**
25/08/96	58.5	47.10	0.29	0.0125	0.49
29/08/96	27.0	22.10	0.37	0.0125	1.33*
06/09/96	120.0	351.00	1.60	0.0125	0.37
10/09/96	19.0	18.9	0.13	0.0125	0.55
24/09/96	19.1	18.9	0.11	0.0125	0.46
23/10/96	58.0	97.5	0.50	0.0125	0.41
Weighted mean					**0.39**

26/08/97	33.0	57.3	0.25	0.008	0.54
23/09/97	19.0	20.0	0.09	0.008	0.56
01/12/97	15.2	10.0	0.05	0.008	0.62
Weighted mean					**0.55**
30/07/98	52.2	67.5	0.43	0.0125	0.50
22/09/98	51.3	62.0	0.19	0.0125	0.24
02/10/98	27.5	30.5	0.73	0.0125	1.91*
Weighted mean					**0.22**
12/06/99	41.0	77.16	0.14	0.008	0.22
19/06/99	54.5	79.20	0.20	0.008	0.31
03/08/99	48.5	58.50	0.11	0.008	0.23
12/09/99	35.5	47.24	0.70	0.008	1.85*
25/09/99	43.6	40.50	0.48	0.008	1.48*
09/10/99	29.0	35.00	0.15	0.008	0.53
Weighted mean					**0.29**
09/07/2000	74.3	189.50	0.94	0.0125	0.38
27/08/2000	77.5	220.13	2.25	0.0125	0.81
29/08/2000	20.5	15.40	0.16	0.0125	0.84
Weighted mean					**0.61**
15/06/2001	114.5	201.40	1.36	0.008	0.84
26/09/2001	60.5	154.20	0.81	0.008	0.66
01/10/2001	46.0	39.30	0.32	0.008	1.01
02/10/2001	22.5	18.72	0.07	0.008	0.47
03/10/2001	18.3	9.73	0.04	0.008	0.51
Weighted mean					**0.56**
Average of weighted mean					**0.43**

*Unfeasible 'C' values

4.9.1.2 Monthly 'C' factor for cotton crop

Monthly 'C' factor was estimated using USLE, taking erosivity and soil loss of particular month. Monthly erosivity, erodibility, soil loss and 'C' factor from cotton plot during rainy season of 1993-2001 (Except 1994) is given in Table 4.10.

Table 4.10 Monthly erosivity, erodibility, soil loss and 'C' factor from cotton plot during 1993-2001 (except 94)

Year and month	Runoff causing rainstorm (mm)	R (metric units)	A (t/ha)	K (t/ha /R)	L	S	C
June-93	96.0	77.96	1.50	0.048	1.69	0.154	1.53*
July-93	199.0	123.16	0.37	0.048	1.69	0.154	0.24
August-93	39.0	35.50	0.20	0.048	1.69	0.154	0.45
Sept.-93	25.0	21.18	0.20	0.048	1.69	0.154	0.75
October-93	24.0	14.70	0.38	0.048	1.69	0.154	2.06*
Weighted mean							**0.34**
June-95	-	-	-	0.033	1.70	0.155	-
July-95	91.0	102.7	0.60	0.033	1.70	0.155	0.73
Aug. -95	-	-	-	0.033	1.70	0.155	-
Sept.-95	30.0	18.52	0.08	0.033	1.70	0.155	0.53
Oct.-95	-	-	-	0.033	1.70	0.155	-
Weighted mean							**0.69**
June-96	-	-	-	0.048	1.69	0.154	-
July-96	16.5	11.04	0.21	0.048	1.69	0.154	1.52*
Aug.-96	85.5	69.20	0.66	0.048	1.69	0.154	0.76
Sept.-96	141.6	377.76	1.63	0.048	1.69	0.154	0.34
Oct.-96	58.0	97.50	0.50	0.048	1.69	0.154	0.41
Weighted mean							**0.39**
June-97	15.2	10.0	0.05	0.033	1.70	0.155	0.62
July-97	-	-	-	0.033	1.70	0.155	-
Aug.-97	33.0	57.3	0.25	0.033	1.70	0.155	0.54
Sept.-97	19.0	20.0	0.09	0.033	1.70	0.155	0.56
Oct.-97	-	-	-	0.033	1.70	0.155	-
Weighted mean							**0.55**
June-98	-	-	-	0.048	1.69	0.154	-
July-98	52.0	64.4	0.43	0.048	1.69	0.154	0.53
Aug.-98	-	-	-	0.048	1.69	0.154	-
Sept.-98	51.3	56.6	0.19	0.048	1.69	0.154	0.26
Oct.-98	27.5	39.0	0.73	0.048	1.69	0.154	1.49*
Weighted mean							**0.40**
June-99	75.5	156.36	0.34	0.033	1.70	0.155	0.27
July-99	-	-	-	0.033	1.70	0.155	-
Aug.-99	47.5	58.50	0.61	0.033	1.70	0.155	1.30*
Sept.-99	59.1	87.7	0.72	0.033	1.70	0.155	1.02*
Oct.-99	29.0	35.00	0.11	0.033	1.70	0.155	0.39

Weighted mean							**0.29**
July - 2000	74.3	189.50	0.94	0.048	1.69	0.154	0.40
Aug - 2000	98.0	235.53	2.41	0.048	1.69	0.154	0.82
Weighted mean							**0.63**
June - 2001	114.5	201.40	1.36	0.033	1.70	0.155	0.77
Sep - 2001	60.5	154.20	0.81	0.033	1.70	0.155	0.65
Oct - 2001	86.6	67.75	0.43	0.033	1.70	0.155	0.60
Weighted mean							**0.60**
Seasonal weighted mean	**336.49**	**443.91**	**3.1**				**0.50**

*Unfeasible 'C' values

From Table 4.10, for year 1993, monthly erosivity and soil loss varied from 14.70 metric units (September-93) to 123.16 metric units (July-93) and 0.20 t/ha (August-93) to 1.50 t/ha (June-93) respectively, whereas the 'C' factor varied from 0.24 (July-93) to 2.06 (October-93).

Maximum runoff causing rainstorm, erosivity and soil observed in sep-96 i.e. 141.6 mm, 377.76 metric units, 1.63 t/ha respectively.Monthly C value varies from 0.24 in July 93 to 0.82 in August 2000 ignoring unfeasible values.

The seasonal weighted mean of 'C' factor ignoring unfeasible 'C' values varied from 0.29 (99) to 0.69 (95).

4.9.1.3 Seasonal 'C' factor for cotton crop

Seasonal cropping management factors for cotton crop during 1993-2001 (except94) at experimental plots of AEEC were estimated using equation 3.8. The results obtained are given in Table 4.11.

Table 4.11 : Seasonal 'C' factor for cotton crop during 1993-2001 (except 94)

Year	R Metric units	A (t/ha)	KLSP	C
1993	272.50	2.65	0.0125	0.76
1995	121.22	0.68	0.0080	0.70
1996	555.50	3.00	0.0125	0.43
1997	87.30	0.39	0.0080	0.55
1998	160.00	1.35	0.0125	0.67
1999	337.60	1.78	0.0080	0.65
2000	425.03	3.35	0.0125	0.63
2001	423.35	2.10	0.008	0.62
Weighted mean				**0.63**

Table 4.11 revealed that seasonal erosivity index of runoff causing storm and total soil loss during crop growing period varies from 87.30 to 555.50 metric units and 0.39 to 2.65 t/ha respectively.

The estimated cropping management factor for cotton crop at experimental plots varies from 0.43 in 96 to 0.76 in 93. The mean cropping management factor for cotton crop is 0.63.

The weighted mean of seasonal cropping management factor from Table 4.11 is 0.63, which is higher as compared to seasonal weighted mean 0.50, calculated from monthly basis from 4.10.

4.9.2 Seasonal 'C' factor for bajra crop

Seasonal cropping management factor for bajra crop during 89, 90, 99, 2000 and 2001 at experimental plots of AEEC were estimated using equation 3.8. The results obtained are given in Table 4.12.

During 89, 90, 1999 and 2001 bajra crop was grown on experimental plot T_1 (KLSP = 0.0125) where as, in 2000 it was grown on plot T_4 (KLSP = 0.008).

Table 4.12: Seasonal 'C' factor for bajra crop

Year	R Metric units	A (t/ha)	KLSP	C
1989	351.70	1.90	0.0125	0.43
1990	822.62	6.10	0.0125	0.59
1999	337.60	2.20	0.0125	0.52
2000	425.03	1.75	0.008	0.51
2001	423.35	3.32	0.0125	0.62
Weighted mean				**0.54**

Table 4.12, revealed that, seasonal erosivity index of runoff causing storm and total soil loss during crop growing period of bajra varies from 337.60 to 822.62 metric units and 1.75 to 6.10 t/ha, respectively.

The cropping management factor was estimated for bajra crop, it ranges from 0.43 (89) to 0.62 (2001) with weighted mean value 0.54.

4.10 CROPPING MANAGEMENT FACTOR OF RUSLE FOR COMMONLY GROWN CROPS AT AKOLA

For estimating C factor for cotton, maize, sorghum, soybean and mung by RUSLE estimated / calculated as given below.

4.10.1 Estimated stage wise Prior Land Use Sub factor (PLU)

Prior land use sub factor expresses the influence on soil erosion of (1) prior cropping (2) dominant tillage (3) soil consolidation (4) time (5) biological activity. These component account for the residual effect of cropping.

PLU sub factor was estimated by using equation 3.11. The variable DEN expresses the effect of surface density changes due to dominant tillage practices on soil erosion. The value of DEN was taken 1 for freshly tilled soil (Dissmeyer and Foster 1981) for each crop.

The initial value i.e. IV is the ratio of soil erosion for a crop at some critical date to continuous non oilseed or small grain cropping sequence i.e normal cropping. The value of IV is 1 for bajra, cotton, maize, mung, urid and 1.4 for soybean crop Table 3.3.

RA is the rate of change of effect of prior cropping per month. The value of RA for selected crop land is zero except oilseed crop like soybean. The value of RA after oilseed crop like soybean is -0.033 per month Table 3.3. Considering 7 months period after harvest of kharif soybean it comes to – 0.23 which is used for estimating PLU.

RS indicates the rate of change of prior cropping per month (lb ac^{-1} in^{-1}) and recommended values of root mass in upper

Table 4.13 : Estimated stage wise prior land used sub factor (PLU) for commonly grown *kharif* crops.

Crops	DEN	IV	RA	T	RS lb ac^{-1} in^{-1}	PLU
Bajra	1	1	0	1	136	0.93
Cotton	1	1	0	1	91	0.95
Maize	1	1	0	1	136	0.93
Mung	1	1	0	1	91	0.95
Sorghum	1	1	0	1	136	0.93
Soybean	1	1.4	-0.23	1	91	1.11

four inches of soil for corn, soybean, cotton, sorghum, winter and spring small grains at different periods after planting is given in Table 3.4. The value of RS for soybean, mung, urid was 91 and for sorghum, maize and bajra was 136 lb ac^{-1} in^{-1}used for estimating PLU

Stage wise prior land use sub factor for few kharif crops are estimated using equation 3.11 and given in the Table 4.13 From the table it is observed that PLU for sorghum, maize and bajra is 0.93 where as for cotton, mung and urid it is 0.95 and for soybean it comes to be 1.11.

4.10.2 Estimated Stage wise Surface Cover sub factor (SC)

The surface cover sub factor was estimated by eq^{n} 3.12. The surface cover sub factor is depends upon coefficient and percentage of ground cover. The coefficient b varies from 0.024 to 0.070 and taken as 0.024.

The crop growth period was classified in four stages 22nd June to 21st July, 22nd July to 21st August, 22nd August to 21st Sep, 22nd Sep to harvest of crop as stages I, II, III and IV respectively.

The percentage of ground cover (M) of crop increase after sowing/planting of the crop. For soybean crop the percentage of ground cover at stage I, II, III and IV were 10, 50, 75 and 70 respectively. The value of M at stage IV is taken less due to defoliation of leaves after maturity of the plant.

For sorghum and maize the percentage of ground cover were taken as 10, 50, 90 during stage I, II and III respectively For mung, crop stages are classified in four stages as 22nd June to 6th July, 7th July to 21st July, 22nd July to 5th August, 6th August to

e 4.14 : Estimated stage wise surface cover sub factor (SC) for commonly *kharif* crops.

s	Variety	Stages							
		I		II		III		IV	
		22nd June to 21st July		22nd July to 21st August		22nd Aug to 21st Sep		22nd Sep to harvest of crop	
		M	SC	M	SC	M	SC	M	SC
e	Ganga –11	10	0.78	50	0.30	90	0.11	90	0.11
hum	CSH – 9	10	0.78	50	0.30	90	0.11	90	0.11
ean	JS –335	10	0.78	50	0.30	80	0.15	70	0.19
		22nd June to 6th July		7th July to 21st July		22nd July to 5th Aug		6th Aug to harvest of crop	
g	AKM – 8803	10	0.78	30	0.48	65	0.21	80	0.14

harvest of crop. The percentage of ground cover for mung was taken as 10, 30, 65 and 80 percent during stages I, II, III and IV respectively.

Estimated stage wise surface cover sub factor are presented in Table 4.14 The value of SC during Ist stage is always higher as there is minimum percentage of ground cover.

The stage wise SC value for sorghum and maize were same i.e. 0.78, 0.30, 0.11 and 0.11 during stage I, II, III and IV respectively. The stage wise SC value for soybean crop was 0.78, 0.30, 0.15 and 0.19 during stage I, II, III.

The stage wise SC value for mung were 0.78, 0.48, 0.21 and 0.14 during stage I, II, III and IV respectively.

4.10.3 Estimated Stage wise Crop Canopy Sub factor (CC)

The crop canopy sub factor is depends upon fraction of land cover by canopy and height of plant. As the land cover increase, CC also increases whereas as height of plant increase CC decreases.

The value of fraction of land surface (FC) covered by canopy for maize crop were 0.10, 0.50, 0.90 and 0.90 and height of plant 1.0, 4.1,5.0 and 5.30 Feet during stage I, II, III and IV respectively. For all the selected crops, as crop growth period increases, the height of plant increases and becomes constant up to stage IV.

In soybean initially FC value increases up to IIIrd stage of the crop and during Ivth stage it decreases due to defoliation of leaves. FC values at different stage are given in Table 4.15.

Table 4.15 : Estimated stage wise crop canopy sub factor (CC) for commonly grown *kharif* crops.

Crops	Variety	Stages											
		I			II			III			IV		
		22nd June to 21st July			22nd July to 21st Aug			22nd Aug to 21st Sep			22nd Sep to harvest of crop		
		FC	H (feet)	CC	FC	H (feet)	CC	FC	H (feet)	CC	FC	H (feet)	CC
Maize	Ganga –11	0.10	1	0.90	0.50	4.1	0.68	0.90	5.00	0.45	0.90	5.3	0.46
Sorghum	CSH – 9	0.10	1	0.90	0.50	3.0	0.62	0.90	4.50	0.42	0.90	5.62	0.49
Soybean	JS –335	0.10	1	0.90	0.50	1.20	0.55	0.75	2	0.38	0.70	2.90	0.43
		22nd June to 6th July			7th July to 21st July			22nd July to 5th Aug			6th Aug to harvest of crop (25th Aug)		
Mung	AKM – 8803	0.10	0.26	0.90	0.30	0.45	0.71	0.65	0.70	0.39	0.80	0.95	0.27

The stage wise canopy sub factor are estimated using 3.13 and presented in Table 4.15 CC value during stages I,II,III and IV of maize, sorghum, soybean and mung ranges from 0.90 to 0.45, 0.90 to 0.42, 0.90 to 0.38 and 0.90 to 0.27 respectively.

4.11 CROPPING MANANGEMENT FACTOR (C) OF RUSLE FOR MAIZE

4.11.1 Estimated stage wise Surface Roughness Sub factor (SR) for maize

Stage wise surface roughness sub factor was calculated by using eq^{n} 3.14. The surface roughness sub factor is having exponential relationship with surface roughness variable (RG). Surface roughness variable depends on random roughness (RB), root mass in lb ac^{-1} in upper four inch of soil (RS) total rainfall since last tillage (RN) as given in eq^{n} 3.15.

To calculate RG, first we find the value of random roughness (RB). Land preparation to sowing of any crop includes field operation of ploughing, harrowing and then drilling/sowing. The random roughness values for different field operations like mould bold plough (5-7 in) is 1.3, spike harrowing is 0.3 and conventional drilling is 0.4 taken from Table 3.5. Summation of all these values of random roughness RB i.e. 2.0 is used for calculation of RG.

Recommended value of root mass in lb ac^{-1} in^{-1} in upper four inch of soil after different days of planting are given in Table 3.4 RS values for the maize crop selected from Table 3.4 as 92, 272, 544 and 544 during stage I, II, III and IV respectively.

RN value was calculated for different crop stages during 1991-2000 by addition of rainfall amount from 22nd June to end of

Table 4.16: Estimated stage wise surface roughness sub factor (SR) for maize.

Years	22nd June to 21st July					22nd July to 21st Aug					22nd Aug to 21 Sep					22nd Sep to harvest of crop				
	RB	RN	RS	RG	SR	RB	RN	RS	RG	SR	RB	RN	RS	RG	SR	RB	RN	RS	RG	SR
1991	2	3.7	92	3.20	0.92	2	18.8	272	1.06	0.97	2	26.61	544	0.59	0.98	2	29.42	544	0.40	0.98
1992	2	3.7	92	3.20	0.92	2	17.93	272	1.20	0.96	2	25.96	544	0.65	0.98	2	28.75	544	0.44	0.98
1993	2	9.90	92	1.3	0.96	2	13.02	272	2.36	0.93	2	18.19	544	1.92	0.95	2	24.07	544	0.85	0.97
1994	2	11.6	92	1.0	0.97	2	18.86	272	1.51	0.98	2	27.69	544	0.51	0.98	2	27.86	544	0.49	0.98
1995	2	12.46	92	0.93	0.97	2	15.00	272	1.8	0.95	2	18.98	544	1.72	0.95	2	19.41	544	2.4	0.93
1996	2	1.75	92	4.18	0.89	2	7.12	272	5.45	0.86	2	19.57	544	1.59	0.96	2	26.37	544	0.61	0.98
1997	2	3.08	92	3.48	0.91	2	6.72	272	5.76	0.86	2	13.92	544	3.50	0.94	2	15.64	544	2.7	0.93
1998	2	2.81	92	3.62	0.91	2	11.13	272	3.11	0.92	2	20.47	544	1.40	0.96	2	28.6	544	0.44	0.98
1999	2	6.8	92	2.07	0.94	2	17.1	272	0.63	0.98	2	22.47	544	0.69	0.98	2	31.93	544	0.28	0.99
2000	2	10.6	92	1.20	0.96	2	12.6	272	2.5	0.93	2	16.9	544	2.30	0.94	2	18.75	544	1.78	0.95

the stage. The actual value of RN is taken in different stage during 1991-2000.

Substituting the value of RB, RN and RS in eqn 3.14, RG is estimated and putting the estimated value of RG in eqn 3.14 the value of SR is estimated for different stages during 1991 to 2000 and presented in Table 4.16.

During stage I, i.e. 22nd June to 21st July the value of RB and RS are 2, and 92 respectively during all the years. RG and RN are varying from 0.93 to 4.18 and 1.75" to 12.46" however SR lies in between 0.89 to 0.97.

During stage II, i.e. 22nd July to 21st August the value of RB and RS are 2 and 272 respectively and RN changes from 6.72 to 18.8 inch. Thus RG value is in range of 0.63 to 5.76 during different years and SR values ranges from 0.86 to 0.98.

During stage III and IV RB and RS remains constant i.e. 2 and 544respectively. The value of RN in the stage III and IV varying during different years however during stage IV it is always higher as compared to stage III in a particular year. In stage III, RG varies from 0.51 to 2.30 and in stage IV 0.28 to 1.78. In stage III and IV SR varies from 0.94to 0.98 and 0.93to 0.99 respectively during the years 1991 to 2000. SR in all the stages varies between 0.86 to 0.99.

4.11.2 Estimated Stage wise Soil Loss Ratios (SLr) For maize

Soil loss ratios were estimated using eqn 3.10. It depends on five sub factors PLU, SC, CC, SR and SM.

The procedure for calculation of PLU, SC, CC, SR is explained earlier pages. The PLU values were taken as 0.95 and 1.11

Table 4.17 : Estimated stage wise soil loss ratios (SLr) for maize crop.

Years	Stages																			
	I					II					III					IV				
	22nd June to 21st July					22nd July to 21st Aug					22nd Aug to 21 Sep					22nd Sep to harvest of crop				
	PLU	SC	CC	SR	SLr	PLU	SC	CC	SR	SLr	PLU	SC	CC	SR	SLr	PLU	SC	CC	SR	SLr
1991	0.95	0.78	0.90	0.92	0.61	0.95	0.30	0.62	0.97	0.17	0.95	0.11	0.42	0.98	0.04	0.95	0.11	0.49	0.98	0.05
1992	1.11	0.78	0.90	0.92	0.72	1.11	0.30	0.62	0.93	0.20	1.11	0.11	0.42	0.98	0.05	1.11	0.11	0.49	0.98	0.06
1993	0.95	0.78	0.90	0.96	0.64	0.95	0.30	0.62	0.96	0.17	0.95	0.11	0.42	0.94	0.04	0.95	0.11	0.49	0.97	0.05
1994	1.11	0.78	0.90	0.97	0.76	1.11	0.30	0.62	0.98	0.21	1.11	0.11	0.42	0.98	0.05	1.11	0.11	0.49	0.98	0.06
1995	0.95	0.78	0.90	0.97	0.65	0.95	0.30	0.62	0.95	0.17	0.95	0.11	0.42	0.95	0.05	0.95	0.11	0.49	0.93	0.05
1996	1.11	0.78	0.90	0.91	0.70	1.11	0.30	0.62	0.86	0.18	1.11	0.11	0.42	0.95	0.05	1.11	0.11	0.49	0.98	0.06
1997	0.95	0.78	0.90	0.91	0.60	0.95	0.30	0.62	0.86	0.15	0.95	0.11	0.42	0.92	0.04	0.95	0.11	0.49	0.94	0.05
1998	1.11	0.78	0.90	0.91	0.71	0.11	0.30	0.62	0.92	0.19	1.11	0.11	0.42	0.97	0.05	1.11	0.11	0.49	0.99	0.06
1999	0.95	0.78	0.90	0.94	0.63	0.95	0.30	0.62	0.98	0.18	0.95	0.11	0.42	0.98	0.04	0.95	0.11	0.49	0.99	0.05
2000	1.11	0.78	0.90	0.96	0.75	1.11	0.30	0.62	0.90	0.17	1.11	0.11	0.42	0.4	0.05	1.11	0.11	0.49	0.95	0.06

during alternate years as prior land use crop were cotton and maize/sorghum. The stage wise value of SC, CC and SR for maize crops are taken from Table 4.14, Table 4.15and Table 4.16 respectively. The value of SM was taken from figure 3.4 of annual precipitation verses Replenishment whenever annual rainfall is above 18 inch the value of replenishment (SM) is taken as 1. The average annual rainfall of Akola is 31.10 inch thus SM was taken as 1.

The estimated values for SLr are given in Table 4.17 Estimated SLr values varies from 0.60 to 0.76, 0.17 to 0.21, 0.04 to 0.05 and 0.05 to 0.06 for stages I, II, III, IV respectively. While comparing stage wise SLr during different year the variation is very less. Value of SLr is always higher in stage I followed by stage II, IV and III during 1991 to 2000.

4.11.3 Estimated Cropping Management Factor (C) for maize

Cropping management factor (C) was calculated by using eq 3.9 and presented in Table 4.18. It depends on SLr and R. i.e. soil loss ratio and erosivity index of respective stages. It was found that maximum erosivity occurred i.e. 33.58 % during stage I followed by 26.83, 25.43 and 14.16 percent during stage II, III and IV respectively. Stage I is most erosive stage among all stages. C factor for cotton varies from 0.13 (1996) and 0.62 (1995).

In 1996 the 'C' factor is minimum i.e. 0.12 this might be due to high erosivity of rainfall storm occur during the IIIrd stage of crop wherever the crop is having the maximum canopy i.e. 90%.

In 1995, the 'C' factor is maximum i.e0.62, this might be due to high intensity of rainstorm occur during Ist stage of crop

Table 4.18 : Estimated cropping management factor for maize.

Years	Stages								C
	I		II		III		IV		
	22nd June to 21st July		22nd July to 21st Aug		22nd Aug to 21 Sep		22nd Sep to harvest of crop		
	SLr_1	R_1	SLr_2	R_2	SLr_3	R_3	SLr_4	R_4	
1991	0.61	17.69	0.17	16.07	0.04	-	0.05	-	0.40
1992	0.72	75.54	0.20	81.49	0.05	73.29	0.06	25.41	0.30
1993	0.64	147.54	0.17	44.80	0.04	56.68	0.05	32.86	0.38
1994	0.76	119.60	0.21	41.97	0.05	71.31	0.06	-	0.44
1995	0.65	236.74	0.17	3.48	0.05	55.48	0.05	-	0.53
1996	0.70	27.20	0.18	200.40	0.05	288.60	0.06	149.05	0.12
1997	0.60	45.60	0.15	31.04	0.04	57.30	0.05	-	0.26
1998	0.71	-	0.19	67.50	0.05	-	0.06	92.5	0.12
1999	0.63	79.20	0.18	70.32	0.04	81.10	0.05	80.84	0.22
2000	0.75	189.5	0.17	-	0.05	235.53	0.06	-	0.36
Stage wise total R		938.74		738.74		710.89		396.06	2795.8
R percentage with seasonal		33.58		26.83		25.43		14.16	
Weighted mean									0.29

whenever the crop canopy is very less i.e. About 10% resulted into high erosion.

During stage III, erosivity factor i.e. 25.43% i.e. quite high but the erosion occurred is very less. This might be due to the high canopy percentage and value of SLr_3 is small i.e. 0.04 to 0.05.

The weighted mean of cropping management factor for maize crop is 0.29.

4.12 CROPPING MANAGEMENT FACTOR (C) FOR SORGHUM CROP DURING 1991 TO 2000

4.12.1 Estimated Stage wise Surface Roughness Sub factor (SR) For Sorghum

Stage wise surface roughness sub factor was estimated by using eqn 3.14 and the results obtained are given in Table 4.19.

Table 4.19 revealed that, RB value is constant for all stages, RN varies in between 1.75 to 12.46, 6.72 to 18.86, 13.92 to 27.69 and 15.64 to 31.83 during stages I, II, III and IV.

RS values were constant for a particular stage during 91-2000 and 92, 272, 544 and 544 during stages I, II, III and IV respectively.

RG values ranges in between 0.93 to 4.18, 1.04 to 3.11, 0.51 to 3.5 and 0.28 to 2.4 during stages I, II, III and IV respectively.

SR for sorghum in all the stages varies between 0.87 to 0.99.

Table 4.19 : Estimated stage wise surface roughness sub factor (SR) for sorghum.

Years	Stage																			
	I					II					III					IV				
	22nd June to 21st July					22nd July to 21st Aug					22nd Aug to 21 Sep					22nd Sep to harvesting				
	RB	RN	RS	RG	SR	RB	RN	RS	RG	SR	RB	RN	RS	RG	SR	RB	RN	RS	RG	SR
1991	2	3.70	92	3.20	0.92	2	18.8	272	1.04	0.96	2	26.61	544	0.59	0.98	2	29.42	544	0.40	0.98
1992	2	3.70	92	3.20	0.92	2	17.93	272	1.2	0.96	2	25.96	544	0.65	0.98	2	28.75	544	0.44	0.98
1993	2	9.90	92	1.3	0.96	2	13.02	272	2.3	0.94	2	18.19	544	1.9	0.95	2	24.07	544	0.85	0.97
1994	2	11.6	92	1.0	0.97	2	18.86	272	1.04	0.97	2	27.69	544	0.51	0.98	2	27.86	544	0.49	0.98
1995	2	12.46	92	0.93	0.97	2	15.00	272	1.8	0.95	2	18.98	544	1.7	0.95	2	19.41	544	2.4	0.93
1996	2	1.75	92	4.18	0.89	2	7.12	272	5.45	0.87	2	19.57	544	1.59	0.96	2	26.37	544	0.61	0.98
1997	2	3.08	92	3.48	0.91	2	6.72	272	5.76	0.87	2	13.92	544	3.5	0.94	2	15.64	544	2.7	0.93
1998	2	2.81	92	3.62	0.91	2	11.13	272	3.11	0.93	2	20.47	544	1.40	0.96	2	28.60	544	0.44	0.98
1999	2	6.80	92	2.07	0.94	2	17.1	272	1.34	0.93	2	22.47	544	0.63	0.98	2	31.93	544	0.28	0.99
2000	2	10.6	92	1.20	0.96	2	12.60	272	2.5	0.94	2	16.90	544	2.3	0.94	2	18.75	544	1.78	0.95

4.12.2 Estimated Stage wise Soil Loss Ratio for Sorghum During 1991 to 2000.

Stage wise soil loss ratio for sorghum crop were estimated by using eqn 3.10 presented in Table 4.20.

Cotton and soybean crops were grown prior sorghum crop alternately during 1991 to 2000 so that PLU is taken as 0.95 and 1.11 during alternate year. The value of SC and CC varies stage wise but for each stage during different years it remain same.

SC for stage I, II, III and IV are 0.78, 0.30, 0.11 and 0.11 respectively. CC for stage I, II, II and IV are 0.90, 0.68, 0.45 and 0.46 respectively. SR varies in between 0.87 to 0.99 during all stages. SLr lies in between 0.67 to 0.78 for stage I, 0.16 to 0.22 for stage II, 0.04 to 0.05 for stage III and 0.05 to 0.06 for stage IV.

4.12.3 Estimated Cropping Management Factor For Sorghum

'C' factor was estimated by using eq^{n} 3.9 and are given in Table 4.21. SLr values are maximum during stage I i.e. 0.78 and minimum during stage III i.e. 0.04. R is maximum i.e. 33.58% during stage I and minimum i.e. 14.16% during stage IV.

'C' factor was found minimum during 1998 as 0.12 followed by 0.13 during 1996.

Maximum 'C' factor observed as 0.55 during 1995 followed by 0.46 and 0.43 during 1993 and 1991 respectively.

The weighted mean of cropping management factor of sorghum is found to be 0.31

Table 4.20 : Estimated stage wise soil loss ratios (SLr) for sorghum

Years	Stages																			
	I					II					III					IV				
	22nd June to 21st July					22nd July to 21st Aug					22nd Aug to 21 Sep					22nd Sep to harvest of crop				
	PLU	SC	CC	SR	SLr	PLU	SC	CC	SR	SLr	PLU	SC	CC	SR	SLr	PLU	SC	CC	SR	SLr
1991	0.95	0.78	0.90	0.92	0.67	0.95	0.30	0.68	0.96	0.16	0.95	0.11	0.45	0.98	0.05	0.95	0.11	0.46	00.98	0.05
1992	0.11	0.78	0.90	0.92	0.78	1.11	0.30	0.68	0.96	0.22	0.11	0.11	0.45	0.98	0.05	1.11	0.11	0.46	0.98	0.06
1993	0.95	0.78	0.90	0.96	0.67	0.95	0.30	0.68	0.94	0.21	0.95	0.11	0.45	0.94	0.04	0.95	0.11	0.46	0.97	0.05
1994	1.11	0.78	0.90	0.97	0.78	1.11	0.30	0.68	0.97	0.22	0.11	0.11	0.45	0.98	0.05	1.11	0.11	0.46	0.98	0.05
1995	0.95	0.78	0.90	0.97	0.67	0.95	0.30	0.68	0.95	0.22	0.95	0.11	0.45	0.95	0.05	0.95	0.11	0.46	0.95	0.05
1996	1.11	0.78	0.90	0.91	0.78	1.11	0.30	0.68	0.87	0.20	1.11	0.11	0.45	0.95	0.05	1.11	0.11	0.46	0.98	0.05
1997	0.95	0.78	0.90	0.91	0.67	0.95	0.30	0.68	0.87	0.20	0.95	0.11	0.45	0.92	0.04	0.95	0.11	0.46	0.94	0.05
1998	1.11	0.78	0.90	0.91	0.78	0.11	0.30	0.68	0.93	0.21	1.11	0.11	0.45	0.97	0.05	0.11	0.11	0.46	0.99	0.05
1999	0.95	0.78	0.90	0.94	0.67	0.95	0.30	0.68	0.96	0.22	0.95	0.11	0.45	0.98	0.05	0.95	0.11	0.46	0.99	0.05
2000	1.11	0.78	0.90	0.96	0.78	1.11	0.30	0.68	0.94	0.22	1.11	0.11	0.45	0.94	0.04	1.11	0.11	0.46	0.95	0.05

Table 4.21 : Estimated cropping management factor for sorghum.

Years	Stages								C
	I		II		III		IV		
	22nd June to 21st July		22nd July to 21st Aug		22nd Aug to 21 Sep		22nd Sep to harvest of crop		
	SLr_1	R_1	SLr_2	R_2	SLr_3	R_3	SLr_4	R_4	
1991	0.67	17.69	0.16	16.07	0.05	-	0.05	-	0.43
1992	0.78	75.54	0.22	81.49	0.05	73.29	0.06	25.41	0.32
1993	0.67	147.68	0.21	44.80	0.04	56.67	0.05	32.86	0.40
1994	0.78	119.60	0.22	41.97	0.05	71.31	0.05	-	0.46
1995	0.67	236.74	0.22	3.48	0.05	55.48	0.05	-	0.55
1996	0.78	27.2	0.20	200.40	0.05	288.60	0.05	149.05	0.13
1997	0.67	45.60	0.20	31.04	0.04	57.3	0.05	-	0.29
1998	0.78	-	0.21	67.50	0.05	-	0.05	92.5	0.12
1999	0.67	79.20	0.22	70.32	0.05	81.10	0.05	80.84	0.25
2000	0.78	189.5	0.22	-	0.04	235.53	0.05	-	0.37
Stage wise total R		938.74		738.74		710.89		396.06	2795.8
R percentage with seasonal		33.58		26.83		25.43		14.16	
Weighted mean									0.31

4.13 CROPPING MANAGEMENT FACTOR (C) FOR SOYBEAN

4.13.1 Estimated Stage wise Surface Roughness Sub factor For Soybean

Stage wise surface roughness sub factor was estimated by eq^{n}3.14 and the results found are given in the following Table 4.22.

The value of RB is 2.0 i.e. constant for all the stages, RN varies in between 1.75 to 12.46, 6.72 to 18.86, 13.92 to 27.69 and 15.64 to 31.84 during stage I, II, III and IV respectively.

RS values were taken as for soybean were taken as 0, 180, 364 and 364 for the stages I, II, III and IV respectively (Table 3.4).During stage I, RG value is zero because RS is zero. During stage II, III and IV it varies in between 0.19 to 6.25.

SR is constant as 1 during stage I as the value of RG is zero. SR in remaining stages II, to IV between 0.84 to 0.99.

4.13.2 Estimated Stage wise Soil Loss Ratios for Soybean

Stage wise soil loss ratios were estimated by using eq^{n} 3.10 and are given in Table 4.23.

Prior cropping system were selected as Maize, Sorghum and bajara alternately for the soybean crop. Thus the PLU values are taken as 0.93 for sorghum, maize and bajra. (Table No. 4.13) stage wise the value of SC and CC are constant for different year but it varies within the stages.

Table 4.22 : Estimated stage wise surface roughness sub factor (SR) for soybean

Years	Stage																			
	I					II					III					IV				
	22nd June to 21st July					22nd July to 21st Aug					22nd Aug to 21 Sep					22nd Sep to harvest of crop				
	RB	RN	RS	RG	SR	RB	RN	RS	RG	SR	RB	RN	RS	RG	SR	RB	RN	RS	RG	SR
1991	2	3.70	0	0	1	2	18.8	180	6.25	0.84	2	26.61	364	0.45	0.98	2	29.42	364	0.45	0.98
1992	2	3.70	0	0	1	2	17.93	180	0.85	0.97	2	25.96	364	0.49	0.98	2	28.75	364	0.49	0.98
1993	2	9.90	0	0	1	2	13.02	180	1.71	0.95	2	18.19	364	3.30	0.91	2	24.07	364	1.85	0.96
1994	2	11.6	0	0	1	2	18.86	180	0.75	0.98	2	27.69	364	0.37	0.99	2	27.86	364	0.37	0.99
1995	2	12.46	0	0	1	2	15	180	1.2	0.96	2	18.98	364	1.30	0.96	2	19.41	364	1.3	0.96
1996	2	1.75	0	0	1	2	7.12	180	3.8	0.90	2	19.57	364	1.20	0.96	2	26.37	364	0.49	0.98
1997	2	3.08	0	0	1	2	6.72	180	4.1	0.89	2	13.92	364	2.60	0.93	2	15.64	364	2.0	0.94
1998	2	2.81	0	0	1	2	11.13	180	2.2	0.94	2	20.47	364	1.67	0.97	2	28.60	364	0.30	0.98
1999	2	6.8	0	0	1	2	17.1	180	0.96	0.97	2	22.47	364	0.80	0.97	2	31.93	364	0.19	0.99
2000	2	10.6	0	0	1	2	12.6	180	1.2	0.96	2	16.9	364	0.26	0.94	2	18.75	364	1.65	0.95

Table 4.23 : Estimated stage wise soil loss ratios (SLr) for soybean crop

Years	Stages																			
	I					II					III					IV				
	22nd June to 21st July					22nd July to 21st Aug					22nd Aug to 21 Sep					22nd Sep to harvest of crop				
	PLU	SC	CC	SR	SLr	PLU	SC	CC	SR	SLr	PLU	SC	CC	SR	SLr	PLU	SC	CC	SR	SLr
1991	0.93	0.78	0.90	0.92	0.60	0.93	0.30	0.55	0.97	0.15	0.93	0.15	0.38	0.98	0.05	0.93	0.19	0.43	0.98	0.07
1992	0.93	0.78	0.90	0.92	0.60	0.93	0.30	0.55	0.93	0.14	0.93	0.15	0.38	0.98	0.05	0.93	0.19	0.43	0.98	0.07
1993	0.93	0.78	0.90	0.96	0.63	0.93	0.30	0.55	0.96	0.15	0.93	0.15	0.38	0.95	0.05	0.93	0.19	0.43	0.97	0.07
1994	0.93	0.78	0.90	0.97	0.63	0.93	0.30	0.55	0.97	0.15	0.93	0.15	0.38	0.98	0.05	0.93	0.19	0.43	0.98	0.07
1995	0.93	0.78	0.90	0.97	0.63	0.93	0.30	0.55	0.95	0.15	0.93	0.15	0.38	0.95	0.05	0.93	0.19	0.43	0.96	0.07
1996	0.93	0.78	0.90	0.89	0.58	0.93	0.30	0.55	0.86	0.13	0.93	0.15	0.38	0.95	0.05	0.93	0.19	0.43	0.98	0.07
1997	0.93	0.78	0.90	0.91	0.59	0.93	0.30	0.55	0.86	0.13	0.93	0.15	0.38	0.91	0.05	0.93	0.19	0.43	0.93	0.07
1998	0.93	0.78	0.90	0.91	0.59	0.93	0.30	0.55	0.92	0.14	0.93	0.15	0.38	0.96	0.05	0.93	0.19	0.43	0.98	0.07
1999	0.93	0.78	0.90	0.94	0.61	0.93	0.30	0.55	0.96	0.15	0.93	0.15	0.38	0.91	0.05	0.93	0.19	0.43	0.98	0.07
2000	0.93	0.78	0.90	0.96	0.63	0.93	0.30	0.55	0.93	0.14	0.93	0.15	0.38	0.94	0.05	0.93	0.19	0.42	0.98	0.07

SC varies from 0.78, 0.30, 0.15 and 0.19 during stage I, II, III and IV.CC varies from 0.90, 0.55, 0.38 and 0.43 for stages I, II, III and IV during the years 1991 to 2000.

SR varies from 0.86 to 0.99 during all years.

Estimated soil loss ratio is maximum during stage I and it varies in between 0.58 to 0.63. During stage II, SLr value varies in between 0.13 to 0.15. During IIIrd and IV th stage, it decreases having values 0.05 and 0.07 for stage III and IV respectively.

4.13.3 Estimated Cropping Management Factor (C) for Soybean

Cropping management factor for soybean crop was estimated by using eq^{n} 3.9 and the results obtained are presented here in Table 4.24.

SLr is maximum during stage I and minimum during stage III. It varies in between 0.63 to 0.05 during all the years.Maximum erosivity occurred during stage I i.e. 33.58% followed by stage II i.e. 26.83%, stage III i.e. 25.43% and stage IV i.e. 14.16%.

C factor for soybean is maximum during 1995 i.e. 0.51 this might be due to high erosive stream during first stage when SLr_1 is also high and minimum during 1996 and 1998 as 0.10 this might due to high erosive storm during stage II and III.

Weighted mean of cropping management factor for soybean is found to be 0.26.

Table 4.24 : Estimated cropping management factor for soybean.

Years	Stages								C
	I		II		III		IV		
	22nd June to 21st July		22nd July to 21st Aug		22nd Aug to 21 Sep		22nd Sep to harvest of crop		
	SLr_1	R_1	SLr_2	R_2	SLr_3	R_3	SLr_4	R_4	
1991	0.60	17.69	0.15	16.07	0.05	-	0.07	-	0.39
1992	0.60	75.54	0.14	81.49	0.05	73.29	0.07	25.41	0.24
1993	0.63	147.68	0.15	44.80	0.05	56.68	0.07	32.86	0.37
1994	0.63	119.60	0.15	41.97	0.05	71.31	0.07	-	0.37
1995	0.63	236.74	0.15	3.48	0.05	55.48	0.07	-	0.51
1996	0.58	27.20	0.13	200.40	0.05	288.60	0.07	149.05	0.10
1997	0.59	45.60	0.13	31.04	0.05	57.30	0.07	-	0.25
1998	0.59	-	0.14	67.50	0.05	-	0.07	92.5	0.10
1999	0.61	79.20	0.15	70.32	0.05	81.10	0.07	80.84	0.22
2000	0.63	189.5	0.14	-	0.05	235.53	0.07	-	0.30
Stage wise total R		938.74		738.74		710.89		396.06	2795.8
R percentage with seasonal		33.58		26.83		25.43		14.16	
Weighted mean									0.26

4.14 CROPPING MANAGEMENT FACTOR (C) FOR MUNG CROP

4.14.1 Estimated Stage wise Surface Roughness Sub factor (SR) for Soybean

Stage wise surface roughness sub factor was calculated by using eq^{n} 3.14 and are presented in Table 4.25.

RB value is constant i.e. 2 taken during four stages 22nd June to 6th July, 7th July to 21st Aug, 22nd July to 5th Aug and 6th Aug to harvest of crop during the years 1991 to 2000.

RN varies in between 0.62 to 6.45 for stage I, 2.20 to 13.06 for stage II, 5.78 to 14.93 for stage III and 10.19 to 20.77 for stage IV during the years 1991 to 2000.

RS values are considered as 0, 272, 364 and 364 for stage I, II, III and IV respectively for mung crop.

RG is 0 during stage I thus the SR value is 1. RG ranges in between 1.02 to 10.10 during stages II, III and IV during 1991 to 2000.

SR varies in between 0.75 to 1for stages II, III, and IV.

4.14.2 Estimated Stage wise Soil Loss Ratio for Mung Crops

Stage wise soil loss ratio for mung was estimated by using eq^{n} 3.10 and are presented in the following Table 4.26.

The sequence of prior to mung crop were considered as bajra, sorghum and maize alternately. Thus the values of PLU were selected 0.93 (Table 4.13).

Table 4.25 : Estimated stage wise roughness sub factor (SR) for mung.

Years	Stages																			
	I					II					III					IV				
	22nd June to 21st July					22nd July to 21st Aug					22nd Aug to 21 Sep					22nd Sep to harvest of crop				
	RB	RN	RS	RG	SR	RB	RN	RS	RG	SR	RB	RN	RS	RG	SR	RB	RN	RS	RG	SR
1991	2	1.80	0	0	1	2	3.00	272	9.7	0.77	2	6.58	364	7.48	0.82	2	18.84	364	1.34	0.96
1992	2	1.00	0	0	1	2	2.20	272	10.8	075	2	5.78	364	8.37	0.80	2	18.04	364	1.50	0.96
1993	2	0.62	0	0	1	2	5.12	272	7.21	0.82	2	13.11	364	3.0	0.92	2	15.03	364	2.29	0.94
1994	2	6.45	0	0	1	2	13.06	272	2.37	0.94	2	14.93	364	2.32	0.94	2	20.77	364	1.02	0.97
1995	2	0.25	0	0	1	2	11.37	272	3.0	0.92	2	13.52	364	2.83	0.92	2	13.79	364	2.72	0.93
1996	2	1.29	0	0	1	2	2.72	272	10.10	0.76	2	7.26	364	6.80	0.83	2	10.44	364	4.36	0.89
1997	2	1.51	0	0	1	2	2.99	272	9.72	0.77	2	6.23	364	7.86	0.81	2	10.19	364	4.51	0.88
1998	2	2.44	0	0	1	2	2.80	272	3.91	0.90	2	8.91	364	5.40	0.86	2	13.35	364	2.90	0.92
1999	2	1.61	0	0	1	2	6.81	272	5.69	0.86	2	12.14	364	3.43	0.91	2	17.11	364	1.71	0.95
2000	2	1.25	0	0	1	2	10.67	272	4.22	0.80	2	10.67	364	4.22	0.89	2	12.87	364	3.10	0.92

Table 4.26 : Estimated stage wise soil loss ratios (SLr) for mung crop.

Years	Stages																			
	I					II					III					IV				
	22nd June to 21st July					22nd July to 21st Aug					22nd Aug to 21 Sep					22nd Sep to harvest of crop				
	PLU	SC	CC	SR	SLr	PLU	SC	CC	SR	SLr	PLU	SC	CC	SR	SLr	PLU	SC	CC	SR	SLr
1991	0.93	0.78	0.90	1	0.66	0.93	0.48	0.71	0.77	0.25	0.93	0.21	0.39	0.82	0.06	0.93	0.14	0.27	0.96	0.03
1992	0.93	0.78	0.90	1	0.66	0.93	0.48	0.71	0.85	0.27	0.93	0.21	0.39	0.80	0.06	0.93	0.14	0.27	0.96	0.03
1993	0.93	0.78	0.90	1	0.66	0.93	0.48	0.71	0.82	0.26	0.93	0.21	0.39	0.92	0.07	0.93	0.14	0.27	0.94	0.03
1994	0.93	0.78	0.90	1	0.66	0.93	0.48	0.71	0.94	0.30	0.93	0.21	0.39	0.94	0.07	0.93	0.14	0.27	0.97	0.04
1995	0.93	0.78	0.90	1	0.66	0.93	0.48	0.71	0.92	0.29	0.93	0.21	0.39	0.92	0.07	0.93	0.14	0.27	0.93	0.03
1996	0.93	0.78	0.90	1	0.66	0.93	0.48	0.71	0.76	0.24	0.93	0.21	0.39	0.83	0.06	0.93	0.14	0.27	0.89	0.03
1997	0.93	0.78	0.90	1	0.66	0.93	0.48	0.71	0.77	0.25	0.93	0.21	0.39	0.81	0.06	0.93	0.14	0.27	0.88	0.03
1998	0.93	0.78	0.90	1	0.66	0.93	0.48	0.71	0.90	0.29	0.93	0.21	0.39	0.86	0.06	0.93	0.14	0.27	0.92	0.03
1999	0.93	0.78	0.90	1	0.66	0.93	0.48	0.71	0.86	0.27	0.93	0.21	0.39	0.91	0.07	0.93	0.14	0.27	0.95	0.03
2000	0.93	0.78	0.90	1	0.66	0.93	0.48	0.71	0.89	0.28	0.93	0.21	0.39	0.89	0.07	0.93	0.14	0.27	0.91	0.03

SC varies from 0.78, 0.71, 0.21 and 0.14 for stage I, II, III and IV respectively during 1991 to 2000. CC varies from 0.90, 0.71, 0.39 and 0.27 for stages I, II, III and IV respectively. SR is 1 during stage I and it varies in between 0.76 to 0.96 for stages II, III and IV during 1991 to 2000.

SLr is maximum i.e. 0.66 for stage I. During stage II SLr varies in between 0.24 to 0.30 and for stage III it is varies in between 0.06 to 0.07 and minimum at stage IV i.e. 0.03.

4.14.3 Estimated Cropping Management Factor (C) for Mung

Cropping management factor (C) was estimated by using eq^{n} 3.9 and the results obtained are given in the Table 4.27.

It was found that maximum erosivity occurred during stage II i.e. 46.23 per cent followed by 26.28 percent, 20.45 percent during stage IV and III respectively. R is minimum during stage I i.e. 7.0 percent. The minimum erosive rain storm occurred during fortnight after sowing of crop.

'C' factor for mung is minimum i.e. 0.07 (1996) and maximum i.e. 0.31during 1995. This might be due to no erosive storm during stage I and high erosive storm during stage III when SLr is minimum and crop canopy is maximum. C factor for mung is maximum i.e. 0.31 (95) this might be due to high erosive storm occurs in stage II when crop canopy was not fully developed.

Table 4.27 : Estimated cropping management factor for mung.

Years	Stages								
	I		II		III		IV		
	22nd June to 21st July		22nd July to 21st Aug		22nd Aug to 21 Sep		22nd Sep to harvest of crop		
	SLr_1	R_1	SLr_2	R_2	SLr_3	R_3	SLr_4	R_4	C
1991	0.66	10.84	0.25	6.85	0.06	7.07	0.03	9	0.28
1992	0.66	7.54	0.27	68	0.06	59.70	0.03	31.79	0 16
1993	0.66	15.1	0.26	132.58	0.07	13.20	0.03	31.60	0.24
1994	0.66	24.8	0.30	94.8	0.07	10.37	0.03	31.60	0.28
1995	0.66	19	0.29	217.14	0.07	-	0.03	3.48	0.31
1996	0.66	-	0.24	27.2	0.06	112.80	0.03	87.60	0.07
1997	0.66	29.40	0.25	16.20	0.06	31.04	0.03	57.30	0.20
1998	0.66	-	0.29	-	0.06	67.5	0.03	10.2	0.10
1999	0.66	17.40	0.27	61.80	0.07	58.50	0.03	11.82	0.22
2000	0.66	-	0.28	189.50	0.07	-	0.03	220.13	0.15
Stage wise total R		124.08		814.07		360.18		462.73	
R percentage with seasonal		7.04		46.23		20.45		26.28	
Weighted mean									0.20

CHAPTER – V

SUMMARY AND CONCLUSIONS

Upper 30 cm layer of land is most fertile which is indispensable to all enterprises and non can survive if there is no fertile soil to produce crops. It is essential to have clear understanding of causes for erosion and quantitative information on the factors involved so as to design appropriate soil management systems and erosion control measure.

Reliable soil loss is a valuable design, extension and planning tool. It's most immediate advantage is that a well-defined conservation objective can be formulated namely to reduce soil losses to specified acceptable levels and thereby ensure that maximum safe economic use of each piece of land.

In light of above, the present research work on, "Study on runoff factor and cropping management factor of soil loss equation at Akola" was undertaken with following objectives.

1. To estimate runoff factor of MUSLE
2. To estimate cropping management factor (C) of USLE for cotton and bajra at Akola.
3. To estimate cropping management factor (C) of RUSLE for commonly grown kharif crops at Akola.

The observation recorded at AEEC regarding runoff and soil loss from following four treatments were analyzed.

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1. Sowing along the main slope

2. Contour cultivation along leuceana key hedge.

3.Contour cultivation along vetiver key hedge.

4.Sowing along graded bund.

Runoff factor was calculated for the seven treatments, Sowing along the main slope, Contour cultivation along leuceana key hedge, Contour cultivation along vetiver key hedge 'C' factor of USLE for cotton and bajra were estimated.

'C' factor of RUSLE were estimated for maize, sorghum, soybean and mung.

For T_1, T_2, and T_3 storm wise runoff factor of MUSLE were estimated from the seven year data of peak runoff rate and runoff volume. Yearly average of runoff factor were found to be 529, 636 and 582 respectively for treatment T_1, T_2 and T_3.

Effect of cumulative runoff factor on cumulative soil loss was obtained. The relation is linear and the equations for different treatments given below.

$$Y = -1.39 + 5.8 \times 10^{-3} X - \text{for } (T_1)$$

$$Y = -1.24 + 2.9 \times 10^{-3} X - \text{for } (T_2)$$

$$Y = -0.50 + 1.81 \times 10^{-3} X - \text{for } (T_3)$$

The runoff causing rainstorm varied from 8 to 161 mm whereas the monthly runoff causing rainstorm ranged from zero to 265.5 mm. The seasonal runoff causing rainstorm varies from 131 to

773 mm. In rainy season runoff causing rainstorm occurs 3 to 14 times in a year with an average of 7.

The analysis of 14 years (1998-2001) rainfall data revealed that, on an average maximum depth of rainfall (19.53 cm) occurs in the month of Aug followed by July (16.83) and June (14.72 cm) of monsoon on an average 44.64 percent rainfall in below 1.0cm/hr class 28.01 percent rainfall in 2 to 5 cm class and 9.82 percent in highest intensity class (above 5 cm/hr).

The stage wise erosion index from daily rainfall data of 14 years period (1988-2001). Seasonal erosion index varied from 160 (98) to 1036.71 (88).

The soil erodibility factor 'K' determined using soil erodibility nomograph for treatment T_1, T_2, T_3, T_4, T_5 and T_6 at AEEC found to be 0.048, 0.027, 0.015, 0.03, 0.022 and 0.012 t/ha/R respectively and the calculated L factor. The calculated 'S' factor for all the treatment at AEEC was found to be 0.155.

The estimated cropping management factor by USLE for cotton crop varies from 0.43 in 1996 to 0.76 in 1993 with the mean value of 0.63

The cropping management factor by USLE for bajra crop ranged from 0.43 during 1989 to 0.62 during 2001 with the mean of 0.54.

In RUSLE, from five sub factors (PLU, SC, CC, SR and SM), 'C' factor were estimated for maize sorghum, soybean and mung.

The surface cover sub factor (SC) lies in between 0.78 to 0.11, 0.78 to 0.19 and 0.78 to 0.14 for maize/ sorghum, soybean and mung. Within the stages the value of SC is always higher in stage I.

The crop canopy sub factor (CC) for stage I, II, III and IV were found to be 0.90, 0.68, 0.45 and 0.46 for maize, 0.90, 0.62, 0.42 and 0.49 for sorghum, 0.90, 0.55, 0.38 and 0.43 for soybean and 0.90, 0.71, 0.39 and 0.27 for mung respectively.

The surface roughness sub factor (SR) varied from to during 1991 to 2000 for all four stages of estimated crops.SM value taken as 1, as average precipitation is above 18" during the years 1991 to 2000.

Soil loss ratio (SLr) for maize 0.76 to 0.05, for sorghum 0.78 to 0.04, for soybean 0.63 to 0.05 and for mung 0.66 to 0.03 during 1991 to 2000 respectively.

Cropping management factor (C) varies from 0.13 to 0.62 for cotton 0.12 to 0.53 for maize, 0.12 to 0.55 for sorghum, 0.10 to 0.51 for soybean and 0.07 to 0.31 for mung during 1991 to 2000 respectively.

The weighted mean of C factor for maize, sorghum, soybean and mung were 0.29, 0.31, 0.26, and 0.20 respectively.

The following conclusions are drawn from the results presented above.

1. Maximum runoff and soil loss occurs in sowing along slope treatment as there is no conservation measure adopted to it.

2. About 60 percent rainfall occurs below 2cm/hr intensity which can be conserved and does not contributes effectively to soil loss.

3. 28.03 per cent rainfall is between 2 to 5 cm/hr rainfall intensity. 9.82 per cent rainfall having intensity above 5 cm/hr . For this conservation's planning is necessary because the risk of erosion at higher intensity is more.

4. The average runoff factor for treatment T_1, T_2 and T_3 were 529, 636 and 582 respectively.

5. Effect of cumulative runoff factor on cumulative soil loss is linear for different treatments and they are as

$$Y = -1.39 + 5.8 \times 10^{-3} X - \text{for } (T_1)$$

$$Y = -1.24 + 2.9 \times 10^{-3} X - \text{for } (T_2)$$

$$Y = -0.50 + 1.81 \times 10^{-3} X - \text{for } (T_3)$$

6. For 1000 units of runoff factor, expected soil loss is 5.8, 2.9 and 1.81 t/ha in treatment T_1, T_2 and T_3.

7. PLU values for bajra, cotton ,maize, mung, sorghum and soybean were found to be 0.93, 0.95, 0.93, 0.95, 0.93 and 1.11 respectively.

8. For maize, maize, sorghum and soybean crop SC values ranges from 0.30 to 0.36, 0.11 to 0.21 and 0.11 to 0.19 during stage I, II, III and IV, whereas CC ranges from 0.55 to 0.71, 0.38 to 0.45 and 0.43 to 0.49.

9. The soil loss ratio for maize, sorghum and soybean is always higher in stage I. It varies from 0.14 to 0.22, 0.04 to 0.06 and 0.05 to 0.10 during stage I, II, III and IV.

10. The percent erosivity index for stage I, II, III and IV are 33.58, 26.8, 25.43 and 14.14 during 1991 too 2000.

11. The mean seasonal cropping management factor of USLE for cotton and bajra crop were found to be 0.63 and 0.54 respectively.

12. The mean cropping management factor of RUSLE for maize, sorghum, soybean and mung were found to be 0.29, 0.31,0.26 and 0.20 respectively.

CHAPTER - VI

SUGGESTION FOR FUTURE WORK

Based on the experience of the research work on "Study on runoff factor and cropping management factor of soil loss equation at Akola", the following suggestions are made for future work to improve present research work.

1. To estimate PLU, SC, CC by taking actual observation of canopy and height of plants from the field for different crops and it's varieties.

2. To estimate cropping management factor for other kharif crops and horticultural crops by RUSLE.

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VITA

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THESIS ABSTRACT

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E. Year of awarded of degree	:	2002
F. Major subject	:	Soil and Water Conservation Engineering
G. Total number of pages in thesis	:	117
H. Number of words in thesis abstract	:	201
I. Signature of student	:	
J. Signature, Name and Address of Forwarding Authority	:	

ABSTRACT

The present investigation entitled Study on Runoff Factor and Cropping Management Factor of Soil Loss Equation at Akola was carried out at Department of Soil and Water Conservation Engineering by collecting data from Agro-ecology and Environment Centre, Dr. PDKV, Akola.

Data of peak runoff rate and runoff volume of available seven years was used and average runoff factor for T_1, T_2 and T_3 were estimated by using MUSLE as 529, 636 and 582 respectively.

The relationship between cumulative runoff factor and cumulative soil loss was developed. It is linear and R2 ranges from 0.93 to 0.98 in different treatments.

The data for R,K, L, S and P was collected from AEEC during 1989 to 2001 and soil loss was measured to calculate 'C' factors of USLE were 0.63 and 0.54 for cotton and bajra crop respectively.

PLU, SC, CC, SR and SM sub factor were estimated to estimate soil loss ratio in RUSLE for different kharif crops.

'C' factor of RUSLE was estimated for maize, sorghum, soybean and mung crops and the weighted mean of 'C' factor were 0.29, 0.31, 0.26 and 0.20 respectively.

APPENDIX - A

Runoff causing rainstorm, erosivity, runoff and soil loss in different treatments during 1989 to 1999 at Agro-ecology and Environmental Centre, Dr. P.D.K.V., Akola

	Stormwise runoff Causing rainstorm (mm)	Erosivity (metric units)	T_1		T_2		T_3		T_4		T_5		T_6		T_7	
			Runoff (mm)	Soil Loss (t/ha)	Runoff (mm)	Soil Loss (t/ha)	Runoff (mm)	Soil Loss (t/ha)	Runoff (mm)	Soil Loss (t/ha)	Runoff (mm)	Soil Loss (t/ha)	Runoff (mm)	Soil Loss (t/ha)	Runoff (mm)	Soil Loss (t/ha)
	51.50	131.00	23.72	0.54	20.15	0.34	16.43	0.21								
9	90.80	84.32	31.31	1.04	29.69	0.41	13.97	0.34								
9	44.60	80.18	7.70	0.14	4.30	0.06	0.17	0.001								
9	135.40	164.42	39.01	1.18	33.99	0.47	14.14	0.34								
9	58.00	56.20	6.40	0.18	2.19	0.04	0.46	0.004								
9	58.00	56.20	6.40	0.18	2.19	0.04	0.46	0.004								
9	**244.90**	**351.70**	**69.13**	**1.90**	**53.60**	**0.89**	**30.40**	**0.56**								
0	118.0	361.7	75.70	1.43	58.20	0.77	45.70	0.37								
0	68.0	51.9	20.28	0.49	11.34	0.21	5.58	0.11								
0	33.00	25.6	21.96	0.74	15.50	0.41	13.32	0.20								
0	46.50	67.6	31.03	0.93	24.87	0.44	20.68	0.27								
9	265.5	507.8	148.97	3.59	109.91	1.83	85.20	0.95								
0	97.00	52.34	17.91	0.17	10.58	0.08	9.38	0.04								
0	106.00	55.80	65.41	0.75	41.53	0.34	32.72	0.24								
	203.00	108.14	83.32	1.45	52.11	0.42	42.10	0.28								
0	78.0	79.20	7.89	0.11	4.68	0.05	4.03	0.04								

00	33.0	13.20	9.94	0.13	8 73	0 12	6.94	0.08								
00	10.0	-	2.16	0.04	0 25	-	-	-								
00	47.0	17.70	22.75	0.70	11 36	0 29	9.89	0.21								
00	14.0	1.98	3.26	0.03	2 81	0 02	2.07	0.02								
00	34.50	28.4	4.96	0.11	2 57	0 05	2.36	0.04								
0	216.50	140.48	50.96	1.12	30 40	0 53	25.29	0.39								
00	58.50	7.90	12.98	0.40	4 12	0 11	6.29	0.15								
00	29.50	58.30	3.68	0.07	0 95	0 01	0.48	0.005								
0	88.00	66.20	16.66	0.47	5 07	0 12	6.77	0.15								
00	**773.0**	**822.62**	**299.91**	**6.10**	**197.49**	**2.90**	**159.36**	**1.70**								
2	54.33	60.24	17.54	1.53	12 78	2 68	8.01	1.09	13.20	2.7	1.18	1.02	9 01	1.01	14.80	2.1
2	27.16	15.30	7.77	0.40	6 39	1.35	4.00	0.54	13.37	1.4	0.82	0.04	8.08	0.26	7 40	1
2	81.5	75.54	25.31	1.93	19 17	4 03	12.02	1.63	26.57	4.1	2.00	1.06	17.09	1.27	22.21	3.1
	101.10	41.10	16.46	2.05	11 53	0 28	3.9	0.9	17.07	0.51	9.69	1 0	5 66	0.07	12 98	0.29
	33.83	13.23	5.48	0.02	5 00	0 09	2.10	0 04	5.69	0.30	3.23	0 02	1 89	0 03	4 32	0.09
2	68 07	27.16	10.97	1.03	6 53	0 2	3.00	0 05	11.38	0.12	6.46	0.09	3.77	0 06	8 66	0.19
2	203.00	81.49	32.93	3.10	19 17	0 57	9.01	0.19	34.14	0.93	19.38	1.11	11.32	0.16	25.96	0.58
	51.5	8.47	15.01	0.53	9 08	0 14	8.03	0.09	29.3	0.09	12.3	0.92	10.20	0.43	15.38	0.98
	103.0	16.94	36.01	0.35	18 16	0 27	14.74	0.19	29.81	0.18	11.5	0.89	8.34	1 03	30.76	1.02
2	154.5	25.41	51.02	0.87	27 25	0 41	22.77	0.28	59.11	0.27	23.85	2.81	18.54	1.46	46.14	2.10
92		**182.44**	**109.26**	**5.90**	**69.49**	**5.01**	**43.80**	**2.10**	**119.9**	**5.3**	**63.23**	**4.98**	**46.23**	**2.89**	**94.31**	**5.70**
93	37.5	37.80	21.63	1.02	10 29	0 43	7.84	0.35								
93	39.0	40.16	16.09	0.43	12 19	1 29	14.13	0 34								
93	8 0	-	1.14	0.02	0 96	1 001	-	-								

11.5	-	1.30	0.02	1.17	0.01	0.96	0.01								
96.0	77.79	40.16	1.49	23.71	0.73	22.93	0.70								
18.5	4.58	3.37	0.04	1.42	0.01	0.75	0.01								
46.0	47.23	10.48	0.15	6.21	0.09	2.11	0.03								
8.5	-	2.89	0.04	-	-	-	-								
57.0	38.20	2.47	0.03	1.26	0.01	0.34	0.005								
69.0	33.15	8.40	0.10	5.32	0.07	0.62	0.007								
199.0	123.16	27.61	0.36	14.21	0.18	3.82	0.05								
39.0	35.50	10.61	0.20	3.01	0.03	0.88	0.01								
39.0	35.50	10.61	0.20	3.01	0.03	0.88	0.01								
25.0	21.18	10.12	0.19	3.94	0.04	2.91	0.03								
25.0	21.18	10.12	0.19	3.94	0.04	2.91	0.03								
24.0	14.70	15.12	0.38	7.50	0.18	2.38	0.05								
24.0	14.70	15.12	0.38	7.50	0.18	2.38	0.05								
363.0	**272.50**	**103.62**	**2.65**	**52.37**	**1.19**	**32.92**	**1.15**								
47.5	23.00	5.37	0.15	3.08	0.06	2.67	0.05	5.56	0.17	4.27	0.11	3.58	0.06	4.73	0.13
47.5	23.00	5.37	0.15	3.08	0.06	2.67	0.05	5.56	0.17	4.27	0.11	3.58	0.06	4.73	0.13
128.0	79.73	37.47	1.37	29.72	0.73	25.34	0.56	34.98	1.61	28.18	0.88	23.62	0.60	30.33	1.05
77.0	39.86	13.10	0.30	9.24	0.15	7.27	0.09	14.58	0.35	6.80	0.12	8.91	0.12	10.55	0.21
206.0	119.6	50.57	1.67	98.96	0.88	32.61	0.65	49.56	1.96	34.98	1.00	32.53	0.72	40.88	1.26
37.5	11.73	15.34	0.41	11.10	0.20	8.68	0.13	18.81	0.40	11.32	0.19	9.57	0.11	12.01	0.24
23.1	6.95	3.25	0.07	2.44	0.04	1.96	0.03	3.62	0.10	2.87	0.05	2.20	0.03	3.16	0.06
10.1	2.44	2.02	0.05	1.08	0.05	0.80	0.01	1.87	0.05	1.66	0.03	1.38	0.02	1.79	0.04
45.1	20.85	11.26	0.22	8.08	0.14	6.71	0.11	14.52	0.27	10.72	0.15	9.48	0.09	14.56	0.20

64.0	17.7	24.42	0.44	15.00	0.22	12.63	0.13	27.05	0.66	18.24	0.29	14.56	0.54	22.35	0.42
179.5	59.4	56.29	1.19	37.7	0.62	30.78	0.41	65.97	1.48	44.81	0.71	37.19	0.79	53.87	0.96
26.0	9.13	9.86	0.28	7.18	0.16	4.33	0.09	11.38	0.35	8.91	0.18	8.47	0.14	7.46	0.18
34.0	19.18	14.35	0.54	10.15	0.26	8.90	0.19	15.28	0.65	10.77	0.30	3.93	0.21	12.16	0.40
47.5	25.30	9.31	0.24	6.74	0.14	6.14	0.11	13.75	0.57	9.39	0.24	9.02	0.18	10.74	0.36
107.5	53.61	33.52	1.06	24.07	0.56	9.37	0.39	40.41	1.57	29.07	0.72	21.42	0.53	30.36	0.94
	255.61	**145.68**	**4.07**	**103.81**	**2.12**	**85.43**	**6.5**	**161.5**	**5.18**	**113.13**	**2.01**	**94.72**	**2.1**	**129.8**	**3.29**
43.5	5.68	17.02	1.24	9.47	0.46	7.29	0.39	17.44	0.52	7.84	0.26	4.14	0.27	10.01	0.25
31.0	36.90	15.45	0.52	9.22	0.23	6.85	0.16	16.04	0.46	9.48	0.24	6.96	0.18	12.77	0.34
81.0	70.6	5.33	0.12	-	-	-	-	8.47	0.14	-	-	-	-	2.53	0.02
55.0	102.0	5.40	0.30	2.22	0.09	1.48	0.08	4.82	0.41	2.89	0.18	2.11	0.11	3.20	0.23
23.1	6.14	0.85	0.01	0.32	-	-	-	0.24	-	-	-	-	-	0.17	-
233.6	221.32	44.05	2.19	21.23	0.78	15.62	0.63	47.01	1.53	20.21	0.68	13.21	0.56	26.68	0.84
43.0	13.08	14.75	0.19	10.80	0.13	9.61	0.10	19.20	0.27	9.11	0.07	7.63	0.06	14.33	0.17
43.0	13.08	14.75	0.19	10.80	0.13	9.61	0.10	19.20	0.27	9.11	0.07	7.63	0.06	14.33	0.17
276.6	**234.4**	**58.8**	**2.38**	**32.03**	**0.91**	**25.23**	**0.73**	**66.21**	**1.80**	**29.32**	**0.75**	**20.84**	**0.62**	**43.01**	**1.01**
16.5	11.04	3.17	0.21	-	-	-	-	-	0.20	-	-	-	-	-	-
16.5	11.04	3.17	0.21	-	-	-	-	0.49	0.20	-	-	-	-	-	-
58.5	147.10	4.56	0.29	2.10	0.10	1.69	0.07	6.80	0.26	3.13	0.11	1.87	0.07	4.22	0.19
27.0	22.10	6.98	0.37	2.71	0.13	2.46	0.16	8.36	0.08	3.67	0.13	3.67	0.11	6.16	0.24
75.5	69.20	11.54	0.66	4.81	0.23	4.15	0.23	15.16	0.34	6.80	0.24	5.54	0.18	10.38	0.43
120.0	251.0	24.65	1.60	15.95	0.83	14.70	0.67	20.43	0.87	9.95	0.57	9.07	0.56	14.36	0.85
19.0	18.90	3.73	0.13	1.05	0.03	1.08	0.02	4.86	0.09	2.43	0.08	1.10	0.05	3.41	0.12
19.1	18.90	4.54	0.11	0.91	0.02	0.27	0.01	4.07	0.08	2.37	0.03	1.94	0.02	02.68	0.06

	158.1	388.80	33.92	1.84	17.91	0.88	16.05	0.70	29.36	1.04	14.75	0.68	12.11	0.63	20.45	1.03
	58.0	97.50	13.98	0.50	9.55	0.22	7.69	0.16	12.85	0.54	6.91	0.23	5.86	0.20	8.42	0.32
	308.1	**566.54**	**61.61**	**3.21**	**32.27**	**1.33**	**27.89**	**1.09**	**57.86**	**2.12**	**28.66**	**1.15**	**23.51**	**1.01**	**39.25**	**1.78**
	161.0	498.0	52.30	2.98	32.38	1.28	28.63	1.02	46.13	2.44	27.67	0.95	24.86	0.82	34.14	1.45
	27.5	15.6	5.98	0.27	4.13	0.13	3.67	0.11	5.23	0.23	3.46	0.10	2.64	0.07	4.08	0.15
	188.5	513.0	58.28	3.25	36.51	1.41	32.30	1.13	51.36	2.67	31.13	1.05	27.50	0.89	38.22	1.60
	33.0	57.3	7.51	0.28	4.82	0.14	3.94	0.10	6.78	0.25	3.84	0.11	3.07	0.07	4.40	0.13
	33.0	57.3	7.51	0.28	4.82	0.14	3.94	0.10	6.78	0.25	3.84	0.11	3.07	0.07	4.40	0.13
	19.0	20.0	4.38	0.12	2.71	0.05	1.86	0.03	3.58	0.09	1.96	0.04	1.27	0.02	2.86	0.06
	19.0	20.0	4.38	0.12	2.71	0.05	1.86	0.03	3.58	0.09	1.96	0.04	1.27	0.02	2.86	0.06
	15.2	10.0	2.73	0.06	1.55	0.03	1.06	0.02	2.13	0.05	1.29	0.02	0.92	0.01	1.74	0.01
	15.2	10.0	2.73	0.06	1.55	0.03	1.06	0.02	2.13	0.05	1.29	0.02	0.92	0.01	1.74	0.01
	255.70	**87.**	**72.90**	**3.71**	**45.59**	**1.63**	**39.16**	**1.28**	**63.85**	**30.06**	**38.22**	**1.22**	**32.76**	**0.99**	**47.22**	**1.80**
	52.2	67.5	11.82	0.43	6.35	0.18	5.67	0.14	9.71	0.15	4.30	0.13	3.98	0.23	5.45	1.29
	52.2	67.5	11.82	0.43	6.35	0.18	5.67	0.14	9.71	0.15	4.30	0.13	3.98	0.23	5.45	1.29
	51.3	62.0	7.79	0.19	4.96	0.10	4.32	0.09	6.83	0.07	3.68	0.05	3.17	0.09	4.26	0.46
	51.3	62.0	7.79	0.19	4.96	0.10	4.32	0.09	6.83	0.07	3.68	0.05	3.17	0.09	4.26	0.46
	27.5	30.5	12.27	0.73	7.61	0.30	6.46	0.25	6.67	0.14	4.84	0.12	4.20	0.17	5.22	1.17
	27.5	30.5	12.27	0.73	7.61	0.30	6.46	0.25	6.67	0.14	4.84	0.12	4.20	0.17	5.22	1.17
	131.0	**160.0**	**31.88**	**1.35**	**18.92**	**0.58**	**16.45**	**0.48**	**23.21**	**0.36**	**12.82**	**0.30**	**11.35**	**0.49**	**14.93**	**2.93**
	41.0	77.16	3.81	0.25	-	-	-	-	2.37	0.14	-	-	-	-	-	-
	54.5	79.20	4.32	0.27	2.72	0.13	2.18	0.09	3.87	0.20	2.27	0.09	1.09	0.04	1.25	0.05
	95.5	156.36	8.13	0.52	2.72	0.13	2.18	0.09	6.24	0.34	2.27	0.09	1.09	0.04	1.25	0.05
	48.5	58.50	25.05	0.22	15.03	0.08	14.81	0.06	23.90	0.11	14.10	008	12.34	0.33	18.92	0.14

	48.5	58.50	25.05	0.22	15.03	0.08	14.81	0.06	23.90	0.11	14.10	0.08	12.34	0.33	18.92	0.14
9	35.5	47.24	13.87	0.76	9.19	0.46	7.73	0.32	12.58	0.70	8.14	0.37	8.16	0.29	10.26	0.51
9	43.6	40.50	12.34	0.54	7.43	0.24	5.28	0.16	11.88	0.48	6.56	0.25	5.24	0.25	9.32	0.30
9	79.1	87.74	26.21	1.30	16.62	0.70	13.01	0.48	24.46	1.18	14.70	0.62	14.30	0.54	19.58	0.81
9	29.0	35.00	6.04	0.16	4.87	0.11	4.12	0.08	5.77	0.15	5.77	0.09	21.32	0.05	5.29	0.11
	29.0	35.00	6.04	0.16	4.87	0.11	4.12	0.08	5.77	0.15	5.77	0.09	21.32	0.05	5.29	0.11
9	**252.10**	**337.60**	**65.43**	**2.20**	**39.24**	**1.02**	**34.12**	**0.71**	**60.37**	**1.78**	**36.84**	**0.98**	**49.05**	**0.96**	**45.04**	**1.10**
	74.3	189.50	24.13	0.94	15.89	0.50	14.30	0.38	23.52	0.68	13.90	0.40	13.04	0.32	17.38	0.57
	74.3	189.50	24.13	0.94	15.89	0.50	14.30	0.38	23.52	0.68	13.90	0.40	13.04	0.32	17.38	0.57
	77.5	220.13	42.24	2.25	22.69	0.89	20.65	0.72	39.58	0.96	20.63	0.73	20.04	0.66	25.19	0.94
	20.5	15.40	7.70	0.16	4.52	0.08	4.08	0.06	6.14	0.11	5.03	0.08	3.79	0.05	5.35	0.09
	98.00	235.53	49.94	2.41	27.21	0.97	24.73	0.78	45.72	1.95	25.66	0.81	23.83	0.71	30.54	1.05
8	**172.3**	**425.03**	**74.07**	**3.35**	**43.10**	**1.47**	**39.03**	**1.16**	**69.24**	**1.75**	**39.56**	**1.21**	**36.87**	**1.03**	**47.92**	**1.62**
	114.5	201.40	29.7	1.82	24.5	1.02	21.2	0.88	31.9	1.06	25.4	0.86	19.5	0.71	24.6	0.9
	114.5	201.40	29.7	1.82	24.5	1.02	21.2	0.88	31.9	1.06	25.4	0.86	19.5	0.71	24.6	0.9
	60.5	154.20	27.6	1.02	16.2	0.47	15.6	0.41	25.4	0.61	14.5	0.38	13.6	0.33	16.9	0.4
	60.5	154.20	27.6	1.02	16.2	0.47	15.6	0.41	25.4	0.61	14.5	0.38	13.6	0.33	16.9	0.4
1	46.0	39.30	7.2	0.33	3.5	0.11	4.1	0.12	7.9	0.32	1.8	0.05	3.9	0.10	4.3	0.1
	22.5	18.72	4.8	0.10	2.8	0.05	1.5	0.02	8.8	0.07	1.2	0.02	2.2	0.03	3.7	-
	18.3	9.73	1.8	0.05	-	-	-	-	1.7	0.04	-	-	-	-	0.6	-
	86.6	67.75	13.8	0.48	6.3	5.6	5.6	0.14	13.4	0.43	3.0	0.07	6.1	0.13	8.6	0.2
01	**261.8**	**423.35**	**71.1**	**3.32**	**47.00**	**42.4**	**42.4**	**1.43**	**70.7**	**2.10**	**42.9**	**1.31**	**39.2**	**1.17**	**50.1**	**1.6**

APPENDIX - B

Details of crop grown in different experimental plots of Agro-ecology and Environment centre during 1990-2000

Year	Crops under different plots						
	T_1	T_2	T_3	T_4	T_5	T_6	T_7
1990	Bajra	Bajra	Bajra	Sorghum	Sorghum	Sorghum	Sorghum
1991	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton
1992	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton	Cotton
1993	Soybean	Soybean	Soybean	Cotton	Cotton	Cotton	Cotton
1994	Ground nut	Groundnut	Ground nut	Maize	Maize	Maize	Maize
1995	Maize	Maize	Maize	Cotton	Cotton	Cotton	Cotton
1996	Cotton	Cotton	Cotton	Maize	Maize	Maize	Maize
1997	Maize	Maize	Maize	Cotton	Cotton	Cotton	Cotton
1998	Cotton	Cotton	Cotton	Maize	maize	Maize	Maize
1999	Bajra	Bajra	Bajra	Cotton	Cotton	Cotton	Cotton
2000	Cotton	Cotton	Cotton	Bajra	Bajra	Bajra	Bajra
2001	Bajra	Bajra	Bajra	Cotton	Cotton	Cotton	Cotton

APPENDIX – C

Estimated stage wise erosivity index (metric units)during 1988 to 2001

Years	Stages				
	22nd June to 21st July	22nd July to 21st August	22nd Aug to 21st Sep	22nd Sep to harvest of crop	Seasonal
	R_1	R_2	R_3	R_4	
1988	462.80	102.35	320.76	150.80	1036.71
1989	165.80	80.90	10.08	-	256.28
1990	55.28	220.22	28.40	86.61	390.51
1991	17.69	16.07	-	-	33.76
1992	75.54	81.49	73.29	25.41	255.73
1993	147.67	44.80	56.68	32.86	282.02
1994	119.60	41.97	71.31	-	232.88
1995	236.74	3.48	55.48	-	295.70
1996	27.2	200.40	288.60	149.05	665.31
1997	45.60	31.04	57.3	-	133.94
1998	-	67.5	-	92.5	160
1999	79.20	70.32	81.10	80.84	311.46
2000	189.5	193.00	27.13	15.4	425.00
2001	201.40	-	154.20	86.6	442.2
Total % of seasonal	1823.53 (37.06%)	1153.54 (23.44%)	1224.33 (24.84 %)	720.07 (14.63%)	4921.53 (100.0%)

APPENDIX – D

A. Determination of RUSLE parameters

1. Prior land use sub factor (PLU) for sorghum

eqn 3.11 $PLU = DEN \times [IV + RA \times T] \times \exp[-5.3 \times 10^{-4} \times Rs]$

DEN is taken as 1, for freshly tilled soil (Dissmiyer and Foster)

IV,RA and T equals to 1,0 and 1 for crop land (Table 3.3)

RS value for upper four inches of soil is 544 lb ac^{-1} given in Table 3.4. Thus, 136 lb $ac^{-1}in^{-1}$

$PLU = 1 \times [1 + 0 \times 1] \times \exp[-5.3 \times 10^{-4} \times 136]$

$= 0.93$

2. Surface cover sub factor (SC) for sorghum for stage I

eqn 3.12 $SC = \exp(-bM)$

b = coefficient ,0.024

M = 10, As crop canopy of sorghum is 10 % of sorghum

$SC = \exp(-0.024 \times 10)$

$= 0.78$

3. Crop canopy sub factor (CC) for sorghum for stage I

eqn 3.13 $CC = 1 - FC \times \exp(-0.1 \times H)$

FC = 0.10, As fraction of land surface covered by canopy during stage I is 0.10 i.e. 10 %

$CC = 1 - (0.10) \times \exp(-0.1 \times 1)$

$= 0.90$

4.Surface Roughness sub factor SR for sorghum (stage I)during 1991.

eqn 3.13 $SR = \exp(-0.026 \times RG)$

For calculation of RG (eqn 3.14)

$RG = \{(25.4 \times RB - 6)\{1-\exp(-1.5\times10^{-3} RS)\}$

$\exp[-0.14 \times RN]$

$RG = [25.4 \times 2 - 6][1-\exp(-(1.5\times10^{-3} \times 92)]$

$\times [\exp(-0.14 \times 3.7)]$

$= [(44.8)(0.12)](0.59)$

$= 3.2$

$SR = \exp(-0.026 \times 3.2)$

$= 0.92$

5. Estimation of soil loss ratio for stage I (SLr_1) for sorghum during 1991

eqn – 3.10

stage – I) $SLr_1 = PLU \times SC \times CC \times SR \times SM$

substituting the values calculated above,

$SLr_1 = (0.93)(0.78)(0.90)(0.92)(1)$

$= 0.67$

similarly, SLr for various stages is calculated.

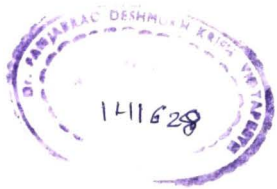
6. Estimation of 'C' factor for sorghum during 1991.

eqn 3.9

$$C = \frac{SLr_1 (R_1) + SLr_2 (R_2) + \text{--------} + SLr_n (R_n)}{R_1 + R_2 + R_3 + \text{---------} + R_n}$$

$$= \frac{0.67 \times 17.16 + 0.16 \times 16.07}{17.69 \times 16.07}$$

$= 0.43$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